STOPPING WATER POLLUTION AT ITS SOURCE

MISA

Municipal/Industrial Strategy for Abatement

BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY - INDUSTRIAL MINERALS SECTOR

Ontario

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BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

INDUSTRIAL MINERALS SECTOR

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and
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ONTARIO MINISTRY OF THE ENVIRONMENT

INDUSTRIAL MINERALS SECTOR

NON-METALLIC MINERALS DIVISION

BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

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EXECUTIVE SUMMARY

Kilborn Inc. (Kilborn) and The Environmental Applications Group Limited (EAG) were retained by the Ontario Ministry of the Environment (OMOE) to undertake a study to identify Best Available pollution control Technologies (BAT) applicable to effluents monitored under the Municipal/Industrial Strategy for Abatement (MISA) program for the Industrial Minerals Sector, Non-Metallic Minerals Division. BAT has been defined by OMOE as a combination of demonstrated treatment technologies and in-plant controls. The Non-Metallic Minerals Division comprises Portland cement, Chemical Lime, Magnesium, Nepheline Syenite, Gypsum, Graphite, Talc, Salt and Basalt.

Specific objectives of the study are:

1) to provide information on existing, or alternate industrial processes, effluent treatment works and processes, chemical substitutions, and employment of water reduction or reuse;
2) to provide relevant information on design specifications, as-found treatment performance, operating conditions, effluent quality remediation and capital and operating costs of the technologies; and
3) to recommend, where possible, five options for BAT for each plant or group of plants within the Division.

Data for the study were obtained from: the MISA effluent monitoring data base, study team files, published documents, and from contacts with a large number of mining and processing operations. Contacts in this latter instance were made through use of a questionnaire and telephone follow-up. In many cases, questionnaires were completed from verbal responses. Confidentiality was an issue with a number of operations, particulary those outside Canada. Site visits were made to operations in Europe to review technologies different from those commonly employed in North America and to selected Ontario operations.

The MISA effluent monitoring data base, for the period August 1, 1990 to July 31, 1991 formed the basis for effluent quality comparison for all monitored Ontario plants. The data base available for this study

was the unedited version for which quality assurance/quality control correction has not yet been applied. From this unedited version, a list of 32 Priority 1 parameters was prepared by OMOE and these parameters were those selected for application of treatment technologies. The main parameters of concern and which are judged to be treatable include: Total Suspended Solids, Oil and Grease, Total Dissolved Solids, Ammonia, Phenolics and pH.

Preliminary toxicity data were available and are discussed within this document but analysis of the data was not completed by OMOE prior to completion of this study. This preliminary data suggests that the majority of the Non-Metallic Minerals Division effluents which were tested are considered to be non-toxic to either Rainbow Trout or Daphia magna.

In addition to a review of operating plants and waste water control technologies, a comprehensive review of generic waste water control technologies which are and could potentially be applied to the Non-Metallic Minerals Division was completed.

To facilitate evaluation of interprovincial and international waste water treatment control technologies, a comparison of applicable world-wide regulations, guidelines and control practices was made. Standards are generally comparable among the areas reviewed with some notable exceptions. Standards for suspended solids, dissolved solids and ammonia are among the more variable ones encountered within the United States. Effluent quality regulations based on production rates are frequently applied to U.S. non-metallic minerals producers. With minor exceptions, ammonia does not appear to be regulated outside Canada or outside the provinces of Ontario, British Columbia and Saskatchewan. Monitoring for toxicity was found to be similarly limited outside of Ontario and British Columbia.

An inventory of world-wide operations was prepared, focusing on Canada, the northern United States and northern Europe. Only a limited amount of data could be obtained from operations outside Ontario for various reasons and in some cases the monitoring protocol is notably different from that applied in Ontario rendering quality values less meaningful.

A review of treatment technologies currently in use within the non-metallic mineral producing and related industries, was carried out to identify those technology trains which meet, or could meet, minimum acceptable Ontario US EPA and World wide BAT requirements. Consideration of Maximum Pollution Prevention and progress towards zero discharge were also considered in this review.

Based on the review, the operations or plants demonstrating the application of BAT are selected on the basis of best overall effluent quality in combination with the application of treatment technology. In certain sub-sectors, the lack of similar or 'sister' plants prevents the selection of a BAT operation. In this latter case, preferred technologies are advocated for treatment of effluents where applicable.

Almost without exception the analysis of regulations, water quality monitoring and treatment technology, illustrates that control of suspended solids is the primary concern to the Non-Metallic Minerals Division. In certain sub-sectors however, control of pH, dissolved solids and oil and grease are shown. For control of suspended solids, various configurations of sumps, settling ponds and decant ponds are the technologies demonstrated by the selected BAT operations. Ammonia and phenolics although treatable, are not subject to specific treatment methods, and are only treated indirectly, within the Non-Metallic Minerals Division.

Within each category or sub-sector, the application of the selected technology in order to attain the effluent quality demonstrated by the BAT plant is assessed. For all such operations, estimates of the required capital and operating costs are shown. In addition to reaching levels demonstrated by Ontario, US and World BAT plants, costs are estimated for attainment of Maximum Pollution Prevention and Zero (Volume) Discharge. Within the Non-Metallic Minerals Division, zero volume discharge is currently attained by a single specialized cement operator.

It must be emphasized that these estimated costs are considered typical for each sub-sector but do not included site specific costs associated with unique conditions, topography, site availability and background water quality. Further work including detailed site investigations and effluent treatment testing would be required to improve the applicability of the cost estimates to specific operations.

Pollution Prevention Practices (PPP) including Best Management Practices (BMP) are employed throughout the industry in an effort to optimize performance, and to minimize environmental impacts. Improving on the efficiency of waste water use and recycle, segregation of cooling and storm water flows avoiding and providing contingencies for process upsets, controlling spillage of ammonia based explosives, and operator training, are among the more common practices. Considering that many of the non-metallic mineral operations handle essentially inert substances, the application of PPP frequently has a significant impact on the quality of effluents produced from the sites.

SECTION 1.

INTRODUCTION

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

1. INTRODUCTION

1.1 TERMS OF REFERENCE

Kilborn Inc. (Kilborn) and The Environmental Applications Group Limited (EAG) were retained by the Ontario Ministry of the Environment (OMOE) to undertake a comprehensive study to identify Best Available pollution control Technologies (BAT) applicable to Industrial Minerals Sector effluents, which are subject to monitoring under the Municipal-Industrial Strategy for Abatement (MISA) program. BAT has been defined by OMOE as a combination of demonstrated treatment technology and in-plant controls. BAT capabilities, once defined, are to be used as a basis for setting effluent limits for Non-Metallic Minerals operations. The choice of any given technology train, however, will be up to the individual operator, so long as the regulations are satisfied (Donyina, 1991, pers. comm).

The Industrial Minerals Sector comprises two Divisions based on product type, Non-Metallic Minerals and Aggregates. This report addresses the Non-Metallic Minerals Division. A separate, companion report addresses the Aggregates Division.

Non-metallic Minerals are herein defined to include cement, chemical lime, magnesium, graphite, gypsum, nepheline syenite, basalt, talc, and salt.

The objectives of this study are:

1) to develop an inventory of water pollution control technologies presently used at industrial minerals plants in Canada, the United States and Europe, focusing on design, operating conditions, performance and capital and operating costs

2) to develop an inventory of generic waste water pollution control technologies used in other industrial sectors (e.g. mining) which could be applied to industrial minerals plants

3) to determine, where possible, up to five technology trains which can be applied to different plant types to achieve BAT option goals

4) to estimate costs and contaminant removal efficiencies for defined BAT options.

The study of applicable technologies was to focus on those industrial minerals currently mined in Ontario, as well as 'sister' operations outside Ontario using demonstrated advanced technologies. 'Sister' plants are defined as, "those plants producing similar products at comparable rates to those produced by Ontario plants in the sector": (OMOE, 1991). The search was generally confined to areas with climatic conditions similar to those found in Ontario.

The process for selection of the BAT options described herein, was to consider the ability of a given, demonstrated technology to remove selected contaminants. The contaminants and parameters of primary interest within the Non-Metallic Minerals Division are: total suspended solids, oil and grease, ammonia/ammonium, phenolics and pH.

In addition, consideration was to be given to the following secondary characteristics of potential BAT options:

- ability to achieve an effluent quality non-lethal to Rainbow Trout and Daphnia magna
- maximum waste water reduction by reuse and recycling
- progress towards virtual elimination of persistent toxic contaminants

For each sector and contaminant of concern, the study was to identify five BAT options (where possible) to satisfy the following criteria:

- a BAT option that utilizes the best technologies currently in use in North America, Europe, and elsewhere
- a BAT option selected by the U.S. Environmental Protection Agency (EPA) for similar plants
- a BAT option that utilizes the best technologies currently in use in Ontario
- a BAT option which produces an effluent which satisfies the OMOE acute toxicity tests for Rainbow Trout and Daphnia magna
- a BAT option that advances the Industrial Minerals Sector towards the MISA goal of virtual elimination of persistent toxic contaminants

From the obtained information a database was to be developed to summarize technical design, operating, performance and cost information for in-plant and effluent treatment technologies, and Pollution Prevention Practices (PPP).

1.2 BACKGROUND

In 1986, OMOE initiated the MISA program (Municipal - Industrial Strategy for Abatement) to strengthen the controls on water pollution from all sources. The ultimate goal of the MISA program is the virtual elimination of persistent toxic contaminants for all discharges to Ontario waterways. In order to better assess the status of water pollution in Ontario, the various industrial/municipal sources were divided into nine categories:

- Petroleum Sector
- Organic Chemical Manufacturing Sector
- Pulp and Paper Sector
- Metal and Mining Sector
- Iron and Steel Sector
- Electric Power Generation Sector
- Inorganic Chemical Manufacturing Sector
- Metal Casting Sector
- Industrial Minerals Sector

Upon promulgation of Ontario Regulation 91/90 (Effluent Monitoring Regulation for the Industrial Minerals Sector) in August 1990, a voluntary pre-regulation monitoring program was established in order to determine effluent characteristics within the sector. The pre-regulation monitoring data identified the parameters most relevant to the Industrial Minerals Sector. These parameters include: suspended solids, pH, ammonia/ammonium, phenolics, and oil and grease. For the salt subsector, chlorides and dissolved solids also are key parameters.

The MISA program consists of two phases. In the first phase, sector specific effluent monitoring regulations were passed into law (e.g. Ontario Regulation 91/90). These regulations required dischargers of waste water to surface watercourses, to monitor their point source discharges at regular intervals according to specific sampling, analysis, quality assurance and quality control protocols and procedures. For Industrial Minerals Sector plants, the monitoring period was August 1, 1990 to July 31, 1991.

The second phase of the MISA program (of which this study is one component) involves the development and implementation of Effluent Limit Regulations for all direct dischargers in all MISA industrial sectors. The Effluent Limit Regulations for Industrial Minerals sector operations will be based, in part, on the capability of the BAT options identified in this study.

The Industrial Minerals Sector includes all non-fuel minerals and rocks which are mined, processed and utilized for purposes other than their metal content. Magnesium, although itself a metal, is considered within the Industrial Minerals Sector since the primary raw material of the Ontario operation is dolomitic limestone.

As mentioned, the Industrial Minerals Sector has been divided into:

i) Non-Metallic Minerals Division

ii) Aggregates Division

This document considers the BAT for the Non-Metallic Minerals Division only. The Aggregates Division is considered within the companion document, Best Available Pollution Control Technology - Industrial Minerals Sector, Aggregates Division.

1.3 NON-METALLIC MINERALS DIVISION

There are over 30 Non-Metallic Minerals plants in Ontario which discharge effluent off-property, although often intermittently (Donyina, 1991, pers. comm). Twenty-three of these plants were monitored under the MISA program. For ease of both implementation of the MISA program, and future regulation, the Non-Metallic Minerals Division is further divided into nine categories:

- cement
- chemical lime
- magnesium (dolomitic limestone)
- graphite
- gypsum
- nepheline syenite
- basalt
- talc
- salt

These categories are based on a combination of factors related to mineralogy, processing methods, mining methods, type of products produced and effluent contaminants.

Due to the varied nature of the Non-Metallic Minerals Division, there are several effluent sources included under the MISA program. These sources include waste water associated with mining, and associated manufacturing facilities. Waters related to mine operations may result from dewatering of underground workings, surface run-off, as well as groundwater seepage into surface workings. Manufacturing related

waters may include cooling water (generally non-contact), water for washing raw materials, process water and water for dust suppression. The effluents monitored under MISA have been classified as:

- Manufacturing or Process Water
- Cement Plant Effluent, Lime Plant Effluent, Graphite Plant Effluent, Gypsum Plant Effluent and Magnesium Plant Effluent
- Mine Water Effluent
- Quarry Water Effluent
- Storm Water Effluent

Section 2 provides a summary of each category considered within the Non-Metallic Minerals Division. Included (where available) is the status of the Ontario industry in relation to other Canadian producers, a brief description of the process, where applicable, as well as the general characteristics of the effluent released from the operation.

1.4 PRIORITY PARAMETERS

The attached Table 1-1 identifies Priority 1 Parameters in effluents from the 23 Non-Metallic Mineral Operations monitored during the period of August 1, 1990 to July 31, 1991. This listing is based upon unedited data for which QA/QC assesment has not been completed.

Discussions with Ministry officials indicate that this preliminary listing is expected to contain all of the Priority 1 Parameters which will be determined from the final edited data. It is also expected that some of the parameters in the preliminary list will not be contained in the final list after editing and QA/QC completion.

The definition of a Priority 1 parameter is: A parameter is given Priority 1, unless a statistically determined 0.90 proportion of the data was less than RMDL (Regulation Method Detection Limit) for that parameter at a 95% confidence level.

Table 1-1 summarizes the Priority 1 Parameters given in the R-15 Report for the Division, along with the number of plants showing this Priority 1 Parameter (out of a total of 23 plants). For comparison purposes, the RMDL is listed adjacent to each parameter.

Each Priority 1 Parameter contained within Table 1-1 is briefly defined in Table 1-2 according to its source where possible, as well as whether the operations which show these parameters are significantly above the RMDL, and whether the parameter is treatable at the levels encountered. The term "not

treatable at levels present" is used for those parameters and concentration levels for which the study team could not find any evidence of industrial scale treatment, applicable to Industrial Minerals Sector plants.

As a result of this listing, the document will focus primarily on the treatment of suspended solids, pH and oil and grease, although other relevant parameters will be discussed.

TABLE 1.1
PRIORITY 1 PARAMETERS LIST
NON-METALLIC MINERALS DIVISION
(12 Month UNEDITED Data from 23 Plants Monitored)

No.	Parameter	Number of Plants where Priority 1 Selected	RMDL Limit	
1	Total Suspended Solids	23	5.0	mg/L
2	Oil and Grease	18	1.0	mg/L
3	Ammonia and ammonium (as N)	17	0.25	mg/L
4	Nitrate + Nitrite (as N)	16	0.25	mg/L
5	Total Kjeldahl nitrogen (as N)	2	0.5	mg/L
6	Phenolics	14	0.002	mg/L
7	pH	7	N/A	
8	Chloride	15	2.0	mg/L
9	Sulphate	15	5.0	mg/L
10	Specific Conductance	14	5.0	mg/L
11	Cyanide	4	0.005	mg/L
12	Total phosphorus	4	0.1	mg/L
13	Dissolved Organic Carbon (DOC)	14	0.5	mg/L
14	Pentachlorophenol	4	1.3	µg/L
15	4-Nitrophenol	3	1.4	µg/L
16	M-Cresol	1	3.4	µg/L
17	O-Cresol	1	3.7	µg/L
18	P-Cresol	1	3.5	µg/L
19	Phenol	1	2.4	µg/L
20	2,4-Dimethylphenol	1	7.3	µg/L
21	Di-n-butyl phthalate	2	3.8	µg/L
22	Toluene	3	0.5	µg/L
23	Zinc	8	0.01	mg/L
24	Cadmium	2	0.02	mg/L
25	Nickel	3	0.02	mg/L
26	Vanadium	1	0.03	mg/L
27	Cobalt	2	0.02	mg/L
28	Copper	1	0.01	mg/L
29	Aluminum	11	0.03	mg/L
30	Arsenic	2	0.005	mg/L
31	Antimony	1	0.005	mg/L
32	Sulphide	5	0.02	mg/L

Note: Preliminary data available March/92 based on Download #1 for the Period August 1/90 to July 31/91

TABLE 1-2
SUMMARY OF PRIORITY PARAMETERS WITHIN THE NON-METALLIC MINERALS DIVISION

Parameter	Associated With Production of:	Possible Source	Regulated Within the Non-Metallic Minerals Division	Treatability
Total Suspended Solids	All categories	Process-related	Yes	Treatable at levels present
Oil and Grease	Sa, Gy, Li, Ce, Gr	Process-related	Yes	Generally not treatable at levels present*
Ammonia/Ammonium	Gy, Li, Ce, Ma, Ba, Sa	Explosive use (ANFO)/agricultural	No	Generally not treatable at levels present*
TKN	Only monitored at salt	Explosive use	No	Not treatable at levels present
Phenolics	Sa, Gy, Li, Ce, Gr, NS	Natural/process-related	No	Not treatable at levels present*
pH	Cement, lime	Process-related	Yes	Treatable at levels present
Chloride	Cement, lime, gypsum, salt	Natural/process-related/road maintenance	Yes (salt only)	Not treatable at levels present
Sulphate	Cement, lime, gypsum, salt	Natural	No	Not treatable at levels present
Specific conductance	Sa, Li, Ce, Gy, Ma, Ta	Natural/process-related	No	Not treatable at levels present
Cyanide	Ma, Li, Sa	Process-related	No	Not treatable at levels present
Total Phosphorus	Ta, Gy, Sa	Process-related/ unknown	No	Not treatable at levels present
Dissolved Organic Carbon	Sa, Gy, Li, Ce, Ma, Ta	Natural, process-related	No	Not treatable at levels present
Pentachlorophenol	Ta, Sa, Ma	Unkown/Natural	No	Not treatable at levels present
4 - Nitrophenol	Magnesium, talc	Unkown/Natural	No	Not treatable at levels present

* Treated incidentally by means of natural degradation during suspended solids treatment.

Sa - Salt
Gy - Gypsum
Ce - Cement
Gr - Graphite
Li - Lime
Ma - Magnesium
Ta - Talc
Ba - Basalt
NS - Nepheline Syenite

TABLE 1-2 (cont'd)
SUMMARY OF PRIORITY PARAMETERS WITHIN THE NON-METALLIC MINERALS DIVISION

Parameter	Associated With Production of:	Anticipated Source	Regulated Within the Non-Metallic Minerals Division	Treatability
M-, 0-, P-Cresol	Lime[1]	Unkown	No	Not treatable at levels present
Phenol	Lime[1]	Unkown/Natural	No	Not treatable at levels present
2, 4-Dimethylphenol	Lime[1]	Unknown/Natural	No	Not treatable at levels present
Di-n-butyl Phthalate	Gypsum[1], salt[1]	Unkown	No	Not treatable at levels present
Toluene	Talc**, salt[1]	Process-related	No	Not treatable at levels present
Zinc	Gy, Ce, Gr, Ta, Ma	Natural	No	Not treatable at levels present***
Cadmium	Talc**	Natural	No	Not treatable at levels present***
Nickel	Li, Ma, Ta	Natural	No	Not treatable at the levels present***
Vanadium	Lime[1]	Unknown	No	Not treatable at the levels present***
Cobalt	Talc[1] **, magnesium	Natural	No	Not treatable at the levels present***
Copper	Lime[1] **	Unkown	No	Not treatable at the levels present***
Aluminum	Ce, Li, Gy, Ta	Natural	No	Not treatable at the levels present***
Arsenic	Talc	Natural	No	Not treatable at the levels present***
Antimony	Talc[1] **	Natural	No	Not treatable at the levels present***
Sulphide	Cement, gypsum	Natural	No	Not treatable at the levels present

* Treated by means of natural degradation during suspended solids treatment.
** At levels close to RMDL.
*** Levels may decrease with suspended solids treatment.
1 At one operation only.

Sa -	Salt	Gr -	Graphite	Ta -	Talc
Gy -	Gypsum	Li -	Lime	Ba -	Basalt
Ce -	Cement	Ma -	Magnesium	NS -	Nepheline Syenite

1.5 SUMMARY OF STUDY METHODS

In order to identify the BAT options for effluent treatment at Non-Metallic Mineral plants, the study team employed a technology search and evaluation methodology that was organized into a number of components. The initial task was the completion of a computer database search using a variety of technical databases. The database search was employed to assemble all available published information regarding treatment technologies applicable to the Non-Metallic Mineral Division.

This task was followed by a review of technologies currently in place at plants in Ontario, Canada, the United States, and in other producing countries with similar environmental conditions. Due to the large number of non-metallic mineral producers outside of Ontario the process was necessarily selective. As a result, certain assumptions were made. The primary assumption used in this report is that the BAT is likely to be found in a highly industrialized country with stringent environmental standards for pollution control. This assumption allowed the search to be focused upon potential 'sister plants' elsewhere in North America, and northern Europe.

From the plants contacted, the study team identified those plants which employed technologies that may be considered for selection as BAT. Where the study team was unfamiliar with the technology, or where further details were required, plants were visited. During the visits, the study team discussed technology performance, efficiency and costs with plant representatives.

All information collected in the data search portion of the study was collated and evaluated with respect to efficiency of effluent treatment, applicability to Ontario operations and the overall objectives of the study, in order to determine the BAT options applicable to each category and parameter of plant operations.

1.6 REPORT FORMAT

The report is presented in a hierarchial order culminating in the selection, description, and costing of recommended BAT options for pollution control. Sections 1, 2 and 3 focus on study objectives, background, approach and data acquisition.

Section 4 provides a brief description of generic technologies potentially available to treat contaminated effluent associated with the Non-Metallic Minerals Division. Some of the methods described are already in common use within the industry. In addition, technologies which are still in the development stages, and technologies which are used in industries other than the non-metallic minerals industry, are also

considered. The intent of this section is to familiarize the reader with technologies referenced elsewhere in the text, and to acquaint the reader with the range of possible technologies.

Section 5 provides a comparison of effluent quality standards applied to non-metallic mineral operations in the geographical areas addressed in this report.

Sections 6 and 7 focus on data acquisition and contact procedures used to develop an inventory of plant operations. Selected BAT options or preferred technologies are recommended based on the data provided within the inventory. The focus within this section has been on those non-metallic minerals currently produced within Ontario.

BAT options are selected, described and costed in Section 8. This section is the focal point of the entire report. Generic technologies or technology trains have been developed for each non-metallic mineral category, or if applicable, descriptions of what might be considered the 'best plants' currently operating. This allows a more meaningful approach to general costing and comparisons. Where there is only one plant representing the category, or where plants within the same category are dissimilar, a technology train approach has been employed, rather than a 'best plant' approach. In either case, assumptions are made regarding the size, configuration, and operations of the systems in order to provide cost comparisons.

Section 9 provides a comprehensive discussion of Pollution Prevention Practices. Within the Non-Metallic Minerals Division, these practices may have a significant impact on effluent quality.

Section 10 summarizes the findings of the study.

Section 11 contains a list of references made in the text of the report and a selected bibliography.

SECTION 2.

INDUSTRIAL MINERALS SECTOR PROFILES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

2. INDUSTRIAL MINERALS SECTOR PROFILES

2.1 CURRENT PRODUCERS

This section contains a brief overview of those non-metallic minerals which are currently produced in Ontario: cement, chemical lime, magnesium, graphite, gypsum, nepheline syenite, basalt, talc and salt.

Cement

Ontario produces more than 40% of Canada's current production; the Western Region produces 27%; Quebec produces 24%; the Atlantic Region produces 4% (Canadian Minerals Yearbook, 1990). There are seven Portland cement producers in Ontario. Of these, six produce grey cement, and one produces a smaller quantity of specialty white cement. The plants are in general, located close to their market and raw material sources, since the product has a relatively low value per unit volume. Most plants have on-site limestone quarries.

Portland cement is produced by heating a mixture containing: calcium carbonate, silica, alumina and typically iron oxide to a sintering temperature to produce clinker by partial fusion. The clinker is then ground to a fine powder with gypsum or anhydrite, resulting in Portland cement. Portland cement is typically combined with water, sand and aggregate to produce concrete for use in the construction industry.

White portland cement is made from iron-free materials to produce a white colour rather than grey. The clinker is quenched in a water spray to ensure that any iron present remains in the ferrous state and therefore avoids colouration by ferric iron compounds.

There has been a gradual shift of production away from processing which includes wet operations such as scrubbers and towards all dry processing. All of the kiln upgrading which has occurred recently in Ontario has included a change to dry processing.

Effluents from cement plants are generally neutral to alkaline in pH. Collection and analysis of effluent samples indicate that the cement plant effluent may contain a concentration of suspended solids and pH

at levels elevated above those recommended as Guidelines in the Ontario Mineral Industry (see Section 5.2 of this report).

Quarry effluent is typically neutral to alkaline and has an increased concentration of suspended solids. Based on limited analyses from storm water effluent at a single plant, storm water effluent is neutral to alkaline in pH, and contains an elevated level of suspended solids.

Chemical Lime

Ontario produces approximately 67% of the total chemical lime output in Canada. Quebec produces approximately 13%, while the rest of Canada's production (20%) is produced in eastern and western Canada. There are nine lime producing plants in Ontario, which are either 'captive' in nature, i.e. send all output to a parent company for use in some other process; or are 'merchant' producers, who supply lime to the open market. Only six of these lime producers were considered within the Industrial Minerals Sector under MISA, and will be subsequently discussed within this document. Merchant producers are preferentially located close to their market (<300 km), due to the high-bulk, and comparatively low-value, nature of lime.

Chemical lime is produced by heating calcium and/or magnesium carbonate rocks (limestone/dolostone) in a kiln (vertical, rotary or Calcimatic), to the dissociation temperature of carbonates for a sufficient period so that carbon dioxide is driven off (calcination). The dissociation temperature is related directly to the quality of the product. Pure calcium carbonate (calcite) requires approximately 900°C to dissociate, while pure magnesium carbonate requires considerably less (400 to 480°C). The dissociation temperature for a particular limestone/dolostone is related to the proportion of each type of carbonate. After dissociation, the product is screened and crushed or pulverized as necessary producing 'quicklime'. If hydrated lime is produced, the crushed and pulverized product is hydrated with water in correct stoichiometric amounts to form the chemically combined hydrate which is dried for sale.

In general, chemical lime plant effluents are neutral to alkaline, and may have elevated levels of suspended solids (above the levels recommended as Guidelines in the Ontario Mineral Industry), which appears to be primarily due to quarrying operations.

Magnesium

There are a total of three plants in Canada which produce magnesium metal; one in each of Quebec, Ontario, and Alberta. The total production from these plants is 58,500 tonnes per year. Canadian

consumption is approximately 15,000 tonnes per year. The total world production is 335,700 tonnes per year, of which the major producing country is the United States (164,000 tonnes per year, 49% of total world production). Canada produces 17.5% of the world production.

Magnesium may be produced by several different methods. In Ontario, high purity magnesium (99.95% pure) is produced using the Pidgeon process. In this process, calcined dolomitic limestone is reduced by ferrosilicon in a vacuum retort. Magnesium is used in a variety of applications, including its major application as an alloying agent for aluminum.

Both magnesium plant effluent and storm water is released to the environment by the one magnesium plant in Ontario. The concentration of priority parameters within the effluent is generally low, and no formal effluent treatment system is used on site.

Graphite

There is only one small commercial producer of graphite in Ontario although two other properties are reported to be in the later stages of development. Outside of Ontario, there is only one large operation in Canada (20,000 tonnes per year product). Canada imports the majority of its requirements from the United States (90%). Canadian operations sell much of their production in the USA and offshore due to marketing arrangements. Graphite is used in brake linings, the manufacture of crucibles, electric motor components, as a lubricant, in the manufacture of pencil lead and for special high temperature components.

The processing method employed reflects the physical and chemical properties of the graphite deposit, and the final product. In Ontario the ore is processed by crushing and grinding to release the crystalline flakes followed by flotation for upgrading. The flotation products are dried, sized and bagged for shipment.

Effluent from the one graphite plant in Ontario consists of three effluent steams: graphite plant effluent, quarry water effluent, and storm water. The effluent is mildly acidic, likely reflecting background water conditions, and occasionally has an increased suspended solids concentration.

Gypsum

Ontario produces only a small percentage (approximately 13%), of Canada's production of gypsum from natural sources. By comparison Atlantic Canada accounts for 75% of Canada's output, and nearly all of

its exports. There are three gypsum operations in Ontario. Two plants process gypsum on-site, while the third ships gypsum to an off-site processing facility.

The most common application for gypsum is in the manufacturing of wallboard. In this process, crude gypsum is crushed, pulverized and calcined to form stucco. Wallboard is produced by compressing a slurry of stucco, water, foam, pulp and starch, between two rolls of absorbent paper. Crushed gypsum is also used in Portland cement production, for agricultural purposes, and for use as a filler.

The three gypsum plants in Ontario release mine water effluent, and at one site, process water effluent. Preliminary data suggest that the effluent may contain increased concentrations of suspended solids, and occasionally increased levels of oil and grease.

Nepheline Syenite

There is one quarry in Ontario serving two processing plants, which produce nepheline syenite for use primarily in glass making and ceramics, as well as an extender in other products. The processing includes the quarrying of rock, crushing and screening to size, and then high intensity magnetic separation for removal of iron. Effluents released from site have been designated as: quarry water, process plant water decanted from the tailings ponds, and storm water.

Basalt

Basalt rock, commonly termed traprock, is quarried at one site in Ontario. After crushing and screening, the rock is coloured for use as roofing granules in the manufacture of asphalt shingles. Only quarry water is discharged off-site.

Talc

There are three companies and four plants in Canada which produce talc; two plants are located in each of Ontario and Quebec. Ontario produces approximately 60% of Canada's output. Talc is used for a wide variety of applications depending upon the physical and chemical properties of the deposit. High purity talc may be used for talcum powder, as well as in the manufacture of ceramicware, fine paper, and paint.

The two Ontario operations use slightly different processes to produce talc. At one site using dry processing, high quality platey talc is produced by mining, crushing, grinding and classification. At the other Ontario plant, the mined talc is treated in a flotation circuit to remove a magnesite gangue, then dried and ground to micron sizes. At this plant a tailings pond is used to store the plant reject solids.

The talc producers in Ontario release either minewater effluent or quarry water effluent, depending upon whether the mine workings are located above, or below, ground. Effluents at both plants show occasionally high levels of suspended solids.

Salt

Both Ontario salt producers recover salt from underground deposits by rock salt mining and brine/solution mining.

Salt recovered from rock salt mining is crushed, screened and packaged for shipping. The main product is de-icing salt for highway use, with the remainder used in the chemical industry. Wet scrubbers are used at one plant in the packaging area to remove salt dust from the surroundings by dissolving the salt in water. Water used in the scrubbers is usually discharged after a once-through use.

The rock salt mining process is essentially a dry operation. Water use in the mine is limited to equipment washings, which is collected and either distributed along the underground roads for dust control, or periodically pumped to surface for discharge. Minor seepages and condensate from ventilation air are the only other source of water in the mine and these are collected and periodically pumped to surface for discharge. Where surface crushing is employed waste salt may be temporarily stored in outside piles. Run-off from these piles is a source of high salinity effluents during periods of precipitation, and is difficult to collect for treatment.

Brine or solution mining involves the pumping of water down injection wells to displace a more saturated solution from withdrawal wells. Salt is then recovered from the brine solution by evaporation to produce salt for human consumption and agricultural uses. In Ontario, a 3- or 4- effect distillation process or "vacuum pan" evaporation system is used. Effluents from the evaporative process consist of evaporative bleed streams, condensate, condenser cooling water, washing of spills and scrubber water.

SECTION 3.

DATA SOURCES AND ACQUISITION PROCEDURES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

3. DATA SOURCES AND ACQUISITION PROCEDURES

3.1 DATA SOURCES

Data sources used in the study include: technical databases, the study team's knowledge of selected operations, discussions with site personnel and other contacts familiar with a given site's operations, U.S. EPA documentation and, in Ontario, a review of the initial reports submitted under the MISA program. The focus and methods of data collection are described in the following sections.

3.2 GEOGRAPHIC FOCUS

The terms of reference specified that the study should focus on Ontario as well as those areas of the world where technological development and environmental awareness are similar to or better than Ontario standards, and where mineral occurrences and mining methods are similar. Where the application of waste water treatment technologies was determined to be climate dependant, search efforts were to be directed to producing areas with a climate similar to Ontario. Accordingly, the study team focused the technology search in the following areas: Canada, northern United States, and northern Europe.

3.3 COMPUTER DATABASE SEARCH

Applicable pollution control databases were searched on-line using combinations of keywords. Keywords such as; wastewater treatment, effluent treatment, mining, mineral, and best available control technology, were used to locate publications which would apply to waste water treatment at non-metallic mineral sites.

The CAN-OLE system (Canadian On-Line Enquiry System) is the most comprehensive collection of Canadian databases. ELIAS (Environmental Library Integrated Automated System) and MICROLOG (Micromedia Catalogue System) are two of the databases searched through this network. An on-line search of the ELIAS database revealed relevant documents of the more than 20 libraries which participate in the Environment Canada Departmental Library Network. The MICROLOG database provided access to literature and reports from all levels of Canadian government as well as universities,

research institutions, laboratories, professional societies, corporations, consultants, associations and special interest groups.

Other sources of non-Canadian government documents were accessed through CODOC (Co-Operative Documents System), NTIS (National Technical Information System), ORD BBS (Office of Research and Development Bulletin Board System), and the RREL (Risk Reduction Engineering Laboratory) Treatability database. CODOC comprises the government document holdings of 11 academic libraries in Ontario. Publications from Canada, the United States, the United Kingdom, France, Germany and the USSR are included in the database. NTIS in the United States carries documents for distribution from over 240 U.S. government agencies. The ORD BBS and the RREL Treatability database are two U.S. EPA technical databases.

The Northern Database (Boreal - The Northern Database) and the Northern Miner Magazine index provided information on technologies utilized in Northern Ontario. Pollution Abstracts and Enviroline cover exclusively environment-related literature and provided a comprehensive index to over 5000 international publications and references on environmental literature. Technology specific to mining was searched on the IMMAGE database through the Institute of Mining and Metallurgy in London, England. Other scientific and engineering databases accessed included Scisearch, Current Technology Index, Compendex and CA Search.

3.4 SITE SPECIFIC DATA ACQUISITION

Existing plants were identified through review of various publications and personal contacts. Some of the key documents/contacts are listed below:

- Canadian Minerals Yearbook
- Canadian Mines Handbook
- Canadian Portland Cement Association
- United States Portland Cement Association (and publications)
- United States Department of Labour (MSHA publications)
- Metals and Minerals Annual Review
- Mining Annual Review
- Industrial Minerals Directory

In addition, contacts were also identified by embassies or industrial trade organizations or the study team's mining contacts world-wide. Information regarding plants was obtained by a number of means

including: a review of MISA initial reports (Ontario operations only), as well as, a brief questionnaire sent to select plants, discussions with plant personnel, review of related technical articles, and site visits.

Questionnaires were developed for each of the Non-metallic Mineral Division categories. The topics addressed by the questionnaire included: methods of quarrying (mining), processing operations, water use / collection on site, sewage treatment, storage of materials, methods of waste water treatment and other pollution control measures. These questionnaires were sent to all Ontario non-metallic mineral operations, a majority of Canadian operations, and to selected United States operations.

Within Ontario, the questionnaire was moderately well received, with several of the respondents including information beyond what was requested. Outside of Ontario however, the response rate was very poor. Follow-up phone calls encouraged response from some of the companies approached, however a large number of operations declined to provide information.

Where no response was received from the questionnaire (or where a questionnaire had not previously been sent), the sites were contacted directly by telephone. A sheet was developed to assist in the collation of information by study team members during discussions with site personnel. This collation sheet addressed: plant age/process technology age; process and design capacity; products; raw materials; water use/reuse/recycle; flow of waste water; technical specifications; effluent quality and effluent related regulatory requirements.

In certain instances, rather than determining the waste water treatment system currently in use at specific plants, manufacturers/developers of specific technologies were contacted. These contacts then provided the names and locations of plants in which their technology was currently in use, and provided another source of information outside of direct plant contacts.

The following sections describe in more detail, the identification and screening procedure according to geographic location.

3.4.1 <u>Ontario Non-Metallic Mineral Operations</u>

Simultaneous to the questionnaire survey, the study team reviewed the MISA initial reports submitted by each non-metallic mineral direct discharger. An inventory sheet was completed for each operation from this information. Based on this review of MISA data, and responses to questionnaires, the effluent treatment systems and their effectiveness were evaluated. The study team then selected representative

or comparatively unique operations from which to collect further information (either by telephone or site visit).

Visits were made to eleven sites in Ontario, encompassing eight of the non-metallic mineral categories including two sites visited within each of the cement, chemical lime and salt categories.

3.4.2 Canadian Non-Metallic Mineral Operations Outside Ontario

A list of plants outside of Ontario was generated from a variety of sources. Several of the non-metallic mineral categories have associations, from which a list of member companies was acquired. Other facilities were located by means of the Canadian Minerals Yearbook or other publications. The final source of information was from lists requested from individual provincial governments. This contact was the least helpful, but did provide the names of some operations.

A select number of operations were either requested to complete a questionnaire similar to that sent to Ontario producers, or were contacted directly. If contacted directly, an inventory sheet was filled out by the study team member during telephone discussions. The technology information received from these two sources was then screened in a manner similar to the Ontario information.

3.4.3 United States Non-Metallic Mineral Operations

Non-metallic mineral operations in the United States were identified using the Industrial Minerals directory, contacts with relevant associations, and a listing compiled by the United States Department of Labour, Mine Safety and Health Administration (MSHA). The listing includes all mines and non-metallic mineral producers currently active, along with their addresses, and average number of workers; while the directory provides a list and brief description of all non-metallic, non-fuel mineral producers.

Questionnaires were mailed to selected operations, chosen primarily on the basis of their location (i.e. climate), and number of employees. The assumption was that locations with a negative water balance (i.e. generally southern locations), and a small number of employees, would be unlikely to require, or have the capital funds available to employ state-of-the-art waste water treatment technology. Due to the very poor response rate to the questionnaires from the United States operations, certain sites were contacted directly by telephone. As with the Canadian producers, a study team member completed an inventory sheet during these discussions.

3.4.4 European Non-Metallic Mineral Operations

Initial contact was made with the foreign embassies of selected non-metallic mineral producing countries. Based on results from these contacts, as well as a literature search applicable to the producing countries, the principle focus was directed to: France, United Kingdom, Germany, Sweden, Norway, and Finland. This focus takes into account climatic conditions which are similar to those of Ontario, and the knowledge that these countries in general, possess superior technology and employ stringent environmental standards.

Within these selected countries, individual companies were contacted by means of the Industrial Mineral Directory. As with other companies contacted, questionnaires were completed either by the plant personnel, or by the consultants during discussions with the site.

Differences in languages spoken as well as a general lack of interest in international contact hampered the collection of information from many overseas operations. Several operations were suspicious, or could not see a benefit to assisting in the study. This attitude derives in part from the often local nature of non-metallic mineral production and competitive marketing, which is in direct contrast to attitudes within the Metal Mining Sector where operations tend to be more international in their outlook.

3.5 SITE VISITS

In order to better ascertain the effectiveness of waste treatment technologies currently in use, site visits were conducted to operations in Ontario, as well as to operations in Germany and the United Kingdom. Visits to these operations were arranged in order to obtain a more detailed understanding of the workings of the site, the waste water treatment systems in place and to obtain specific treatment data.

SECTION 4.

OVERVIEW OF AVAILABLE EFFLUENT CONTROL TECHNOLOGIES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

4. OVERVIEW OF AVAILABLE EFFLUENT CONTROL TECHNOLOGIES

Removal technologies for water contaminants identified as primary concerns by the MISA program that are present in non-metallic mineral wastewaters (suspended solids, pH, ammonia/ammonium, phenolics, oil and grease, and dissolved solids) are described in the following sections. The technologies are categorized according to the type of contaminant removed and are rated according to their utilization in the non-metallic mineral industry as follows:

widely used	-	a commonly used method of treatment
limited use	-	an occasionally used method of treatment
unique	-	employed at one or two related sites
pilot	-	demonstrated site performance at less than full commercial scale
potential	-	a method that could be used but is not, due to economics, performance, limited development or present use confined to other industries

4.1 SUSPENDED SOLIDS

Widely used

- settling ponds
- sumps

Limited Use

- tailings ponds
- coagulants/flocculants
- exfiltration
- passive filtration
- wetland filtration

Unique

- mechanical clarifiers

Potential

- mechanical filtration
- filtration beds

Settling Ponds (widely used)

The mechanism of solid/liquid separation in settling ponds is "free" or "ideal" settling in which solid particles settle independently of one another. The settling velocities are governed by Stoke's Law which relates particle size and specific gravity to the free settling velocity. In an engineered settling pond the area and shape of the pond are designed to reduce the solution upflow or carrying velocity to below the settling velocity of the solids particles to be settled.

principal advantages/disadvantages

- proven effective at a majority of operations
- uses local materials
- reasonable capital cost and low maintenance
- amenable to possible use of flocculants/coagulants if required
- topography may aid in reducing earthworks
- catchment of precipitation and run-off will increase total flow of effluent

The design of a settling pond is dependent upon a number of factors which include the following:

- expected range of concentration of suspended solids in the influent
- size distribution of suspended solids in the influent
- required retention time for solids settlement
- expected range of water temperature
- expected range of flow rate of the influent
- expected flow characteristics within the pond
- maximum allowable concentration of suspended solids in the effluent

Sumps (widely used)

Sumps are used to collect wastewater from underground mines and quarries. Suspended solids are settled in the sump reservoir to produce an effluent suitable for discharge or further treatment. Suspended solids are periodically removed from the sump for disposal within the mine or quarry.

principal advantages/disadvantages

- required for pumping where pit and/or mine water accumulate
- no other feasible alternative
- effectiveness can be maximized through Pollution Prevention Practices
- limited settling area not always as effective as settling ponds for fines
- provides source for recycling water

Tailings Ponds (limited use)

Where wet processing and benefication of raw materials is practised the reject portion of the solids in slurry form (tailings) is usually discharged into an impoundment area where solids settle and are retained. While this is the most common and primary method of tailings disposal, tailings ponds are in limited use in the non-metallic minerals division due to the fact that a small number of operations employ slurry processing. The supernatant liquid is removed using decant towers, syphon systems or barge-mounted pumps. Decant towers have to be raised as the dam wall is raised during the course of time. Barge-mounted pumps are a common method of decanting a tailings area particularly where all or most of the water is used for recycle to the process.

The size of the liquid pond required for satisfactory clarification is determined as for settling ponds.

principal advantages/disadvantages

- combined solid/liquid storage
- low maintenance costs
- large land area and water catchment
- high capital cost unless topography provides a natural basin
- pond must also be sized to provide solids storage for life of plant

Coagulants/Flocculants (limited use)

Coagulants and/or flocculants are added to solutions containing fine particles to promote the growth of larger and consequently heavier particles which have higher settling velocities. The rate of the settling process is increased resulting in a decrease in the settling area required.

principal advantages/disadvantages

- generally have not been employed by the industry to date
- used in special cases where improved settling is required, or where land area for increased settling pond area is unavailable
- can be used in conjunction with mechanical clarifiers

Exfiltration (limited use)

Exfiltration is a type of natural filtration process whereby wastewaters contained in settling or tailings ponds seep through earthen dams, or soils lining the bottom of the pond which act as a filtering medium. As the water seeps through, suspended solids are retained. This mechanism is effective during the initial use of the ponds, but gradually becomes less effective as the soils become clogged, allowing little or no further seepage. Effluent control and monitoring is also sometimes difficult.

principal advantages/disadvantages

- diffuse final effluent, hard to monitor
- eventual clogging
- limited effectiveness

Passive Filtration (limited use)

Passive filtration is a process whereby wastewater is discharged through earthen dams or berms composed of porous aggregate materials. These materials act as a filter to remove suspended solids. This treatment method requires some maintenance to retain a porous medium by changing the discharge location or increasing the dam height. This is required due to the progressive clogging of the porous medium over time.

principal advantages/disadvantages

- achieved inadvertently at several operations, but engineered structures with this objective are in limited use
- appears to be effective at operations where used at reasonable costs
- requires maintenance to prevent pore space clogging

Wetland Filtration (limited use)

Wetlands encompass areas also known as marshes, bogs, wet meadows, peat lands, and swamps. Suspended solids are retained by filtering of suspended and colloidal material from water through the soil and organic mats.

principal advantages/disadvantages

- requires suitable geography, i.e. wetland must be well located on property
- natural wetlands are often regarded as sensitive habitats
- engineered wetlands can be developed, pending land availability and suitable topography
- low capital and operating costs

Mechanical Clarifiers (unique)

This category includes conventional thickeners, reactor clarifiers and plate or tube type clarifiers. Coagulants and flocculants are generally added to facilitate the settlement of the suspended solids. The thickened product can be recycled to increase efficiency and the concentration of the suspended solids in the final sludge before disposal.

principal advantages/disadvantages

- high capital and operating costs
- allow controlled collection of sludge if disposal to another area is required
- generally require flocculant addition due to small settling area
- need surge system on feed to ensure control
- sludge disposal required

Mechanical Filtration (potential)

The separation of suspended solids from liquids by mechanical filtration is effected by the application of a pressure driving force across a physical barrier (e.g. filter cloth or porous medium) which induces the flow of liquid through the barrier. The driving force can be applied using vacuum or pressure. The filter can take many forms such as rotary drum, belt, plate or tube. Filter aids (e.g. coagulants/flocculants) and filter precoats can be used.

principal advantages/disadvantages

- high capital and operating costs
- sludge disposal required
- surge system on feed required
- generally most effective where solids concentration is high

Filtration Beds (potential)

In this method, wastewater is passed through a physically restrictive medium (filtration bed) which results in the deposition of suspended particulate matter. Filtration beds are generally composed of a mixture of granular media, such as sand or anthracite. As the load of suspended solids in the bed increases, so does the head loss, necessitating backwashing. During filter backwashing, the bed is fluidized and settles with the finest particles at the top of the bed. Subsequently, most of the solids are removed from the surface of the bed. Although gravity filtration is effective, pressure filtration has the advantage of operating at higher head losses which improves capacity.

principal advantages/disadvantages

- high capital and operating costs
- sludge is dilute and may require secondary treatment
- sludge disposal required
- good removal of solids from effluent stream

4.2 pH

Limited Use

- sulphuric acid
- carbon dioxide

Unique

- lime
- limestone

Potential

- sodium hydroxide

The supply of nutrients for plants, the release of substances toxic to aquatic life and the toxicity of dissolved substances (e.g. ammonia complexes) are affected by changes in pH.

The pH of wastewaters may be adjusted by the addition of a base if the pH is too low or the addition of an acid if the pH is too high. The addition of an acid or base can be accompanied by the formation of precipitates, which may require collection and disposal, and occasionally deposit on the surfaces of disposal equipment or piping.

The chemical reagents most commonly used for pH adjustment are described below. The classification for the following systems is governed by the number of effluents which require treatment and as a result, even the most common methods are only classified as limited use..

Sulphuric Acid (limited use)

The addition of sulphuric acid lowers the pH to any desired level and eliminates alkalinity by the neutralization of hydroxyl, carbonate and bicarbonate ions. Acid soluble suspended solids (e.g. lime) are dissolved. The sulphate ion, however, increases the concentration of total dissolved solids and may result in scale formation on surfaces of pipes, valves etc. If calcium sulphate precipitate is formed it must be removed by settling in a pond.

The acid storage tank must be surrounded by a dike and protective clothing is required when handling the acid. Safety showers should be installed, and be readily available to operating personnel.

The accepted use of this reagent is due to its fast reaction, availability, and low cost. The acid can be used as a concentrated solution containing up to 93% by weight. A typical installation includes pH monitoring, acid storage and dosing equipment.

principal advantages/disadvantages

- capital cost of installation
- health and safety limitations during handling
- close control of pH requires sophisticated controls to prevent overshooting pH target range due to strength of the reagent
- environmental concern of acid storage system
- possible scale formation

Carbon Dioxide (limited use)

The addition of carbon dioxide in liquid form reduces the pH by reacting with hydroxyl ions to form carbonate and bicarbonate ions. The liquid is vapourized before being introduced into the waste water. By reducing the pH to 9 before discharge, the solubility of calcium carbonate is close to its minimum which occurs at pH 9.5. The calcium carbonate precipitate formed is removed by settling in a pond. A typical installation includes pH monitoring, carbon dioxide storage, dosing and vapourizing equipment.

Carbon dioxide is readily available, safe to handle and ecologically acceptable.

principal advantages/disadvantages

- pH level is easily maintained within set parameters
- health and safety conditions are much improved over the use of sulphuric acid
- application easily controlled
- possible scale formation

Lime (unique)

Lime is the most commonly used chemical for increasing pH in waste waters from plants in other industrial sectors due to its high reactivity, availability, and low cost.

Lime is supplied in either the unslaked form CaO, or in the hydrated form, $Ca(OH)_2$. Unslaked lime is reacted with water to produce hydrated lime in slurry form. This slurry is degritted before being added to adjust pH.

principal advantages/disadvantages

- use within the non-metallic industrial mineral division limited and confined to the treatment of acidic effluents
- where neutralization is required in the related metal mining industry, lime neutralization is the treatment of choice for cost, effectiveness and handling reasons

Limestone (unique)

The use of limestone instead of lime, to increase the pH of waste waters is restricted due to limitations including a slow rate of reaction (unless it is very finely ground), and an inability to raise the pH significantly above 6.0.

Limestone (and lime) can be used in a two stage process to effectively adjust the pH of very acidic waste waters found in other industrial sectors. Limestone is added to increase the pH to between 4.0 and 5.0 followed by lime addition to achieve a pH in excess of 6.0.

principal advantages/disadvantages

- neutralization of strongly acid water rarely required in the industrial minerals sector, where most effluents are neutral to basic
- limestone is less effective than lime, because of limited reactive surface
- fine grinding of the limestone is required to produce a product size with a useful rate of reaction and high utilization

Sodium Hydroxide (potential)

Sodium hydroxide is obtained and may be added as a concentrated solution to increase the pH of wastewaters. The storage tank must be surrounded by a dike and protective clothing must be employed when handling the concentrated solution.

principal advantages/disadvantages

- the rapid rate of reaction
- no slaking or slurrying equipment is required
- storage does not require continuous agitation to maintain homogeneity
- safety precautions required during storage and handling

4.3 OIL AND GREASE

Limited use

- gravity separation

Potential

- air flotation
- activated carbon adsorption

Waste waters contaminated with oil and grease are treated in a variety of ways. Recovery processes include gravity separation, air flotation and activated carbon adsorption. Significant concentrations of these contaminants are often associated with unique or periodic events (such as spillage) which tend to reduce the effectiveness of treatment options.

Gravity Separation (limited use)

Gravity separation is applied in the treatment of wastewaters containing significant quantities of oil. The separation devices are designed to provide sufficient retention time for the oil globules to rise to the surface of the water and coalesce. Baffles are provided to retain the floating oil and allow the passage of water. Skimming devices (e.g. scrapers, slotted pipes) are required to collect the accumulated oil prior to its disposal. Such devices are occasionally installed as interceptors in waste water streams that may be subject to periodic surges of oil/grease related to equipment failure or spillage.

Baffles or booms (with or without absorbing features) may be appropriate for pond systems to retain high concentrations of oil/grease. Gravity separation is effective in removing and recovering unseparated emulsions and large droplets but is not as effective with finely dispersed small droplets or organic wetted particulates.

principal advantages/disadvantages

- not effective for the generally low levels (<3 mg/L) of oil and grease commonly occurring
- where required, is cost effective and requires little attention

Air Flotation (potential)

Air flotation is applied to recover organics which are finely dispersed in liquid streams and is commonly used in other industrial sectors both as a process and for effluent treatment. Oil and grease are contacted by air bubbles introduced either by air jets or as dissolved air.

The column type vertical cell is the simplest device. Finely dispersed organic solution droplets and organic wetted particulates are contacted by the rising air bubbles and carried to the surface where they

are collected. Column type flotation devices do not require complex control and only require a small area for installation.

There are two principle designs of dissolved air flotation systems. In one system, the wastewater is contacted with compressed air and the pressure is released in a flotation tank, generating a fine dispersion of air bubbles. In the other system, air-saturated clarified water is introduced into the flotation tank under pressure through a micro-bubble nozzle as the pressure releasing device. Oil/grease and fine suspended solids become attached to the bubbles and are floated to the surface where a mechanical device is used to skim off the resulting sludge.

principal advantages/disadvantages

- not effective for low levels of oil and grease in non-metallic mineral wastewaters
- costs are greater than those associated with gravity separation
- sophisticated equipment and control systems required for dissolved air systems
- surge system required upstream

<u>Activated Carbon Adsorption (potential)</u>

Activated carbon has a high absorption capacity for organic materials. Dissolved organics are removed by passing the liquid stream through filter beds of activated carbon or anthracite. Specific pollutants are adsorbed on to the activated carbon surface until all active sites are occupied. After saturation the carbon must be regenerated or removed and replaced. Regeneration is possible by either chemical (e.g. solvents) or thermal methods. Spent adsorbent which can no longer be satisfactorily regenerated can be disposed of in a secure landfill or by incineration.

principal advantages/disadvantages

- high capital and operating costs
- carbon retreatment or disposal required
- carbon regeneration results in transfer of removed oil and grease to either the solvent or to stack gases

4.4 AMMONIA/AMMONIUM

Limited Use

- natural degradation

Potential

- nitrification
- break-point chlorination
- ion exchange
- air stripping
- steam stripping

Natural Degradation (limited use)

Natural degradation of ammonia occurs with the transpiration of dissolved ammonia gas from wastewaters by natural means, during retention of wastewaters in holding ponds for extended periods. Ammonia removal is enhanced by increasing pond surface area and aeration. The extent of removal is determined by the pH and temperature of the solution. At neutral and lower pH values, ammonia is mainly present as NH_4+ which does not volatilize effectively.

principal advantages/disadvantages

- requires long retention times in settling/polishing ponds to be effective, and/or elevated pH to assist in ammonia volatization
- efficiency reduced during cold weather

Nitrification - Denitrification

This method involves the biological oxidation of ammonia in a two step process. In the first step (nitrification), ammonia is converted to nitrite (NO_2) under alkaline conditions, followed by nitrite conversion to nitrate (NO_3). The second step (denitrification) involves the reduction of nitrate, to nitrogen gas and water, by contacting the solution with biological solids in the absence of oxygen at a neutral pH level. Carbon, often in the form of methanol, is added to facilitate this anaerobic process when utilized in the municipal sector.

principal advantages/disadvantages

- not employed in the Industrial Minerals or Metal Mining Sectors
- may occur naturally where suitable conditions exist in pond systems

Break-Point Chlorination

Breakpoint chlorination is a technique used to oxidize ammonia from wastewaters to nitrogen gas with the production of small amounts of nitrate and nitrogen trichloride. Chlorine, in the form of chlorine gas or sodium hypochlorite, is added to perform the oxidation process. Alkaline conditions are maintained by the addition of calcium carbonate which is required to neutralize the acid produced during the oxidation process. To eliminate hypochlorite toxicity in the treated effluent, sufficient retention must be provided prior to discharge.

principal advantages/disadvantages

- high capital and operating costs
- chemical addition in the form of chlorine is required
- residual hypochlorite possible in treated effluent

Ion-Exchange

Ammonia can be removed from wastewaters by ion exchange using resins which have a chemical affinity for ammonium cations. Naturally occuring zeolite minerals are known to be more suitable than many synthetic resins. After saturation the medium must be rinsed (stripped) to remove the ammonium compounds, usually with a high pH brine solution. Filtration of the wastewater prior to ion exchange may be necessary to prevent fouling of the medium by suspended solids.

principal advantages/disadvantages

- high capital and operating costs
- disposal of brine and ammonium compounds in rinse solution is required
- filtration prior to ion-exchange may be required

Air Stripping (potential)

Air stripping is typically performed in a packed bed tower with air flowing counter-current to the wastewater containing the dissolved ammonia gas. The transfer of dissolved ammonia gas from the liquid to air is enhanced by the packed bed which serves to maximize the surface area of the liquid exposed to the air. A pH greater than 9 is required to maximize the ratio of ammonia to ammonium ion. As a result of the required high pH level, scaling can become an operational problem if sulphate or calcium (used for pH adjustment by the addition of lime) are present. Temperature of the water is also important, as a decrease in water temperature increases the solubility of ammonia which in turn reduces removal efficiencies.

principal advantages/disadvantages

- effective on concentrated streams
- high capital and operating costs

- not employed in the Industrial Minerals or Metal Mining Sectors

Steam Stripping (potential)

Steam stripping is essentially a fractional distillation process, conducted in a packed tower or conventional distillation column. Wastewater is preheated in a heat exchanger and pumped to enter near the top of the column. As wastewater passes down the column, it is stripped by vapour rising from the bottom of the column. At the bottom of the column, solution is further heated by incoming steam to reduce ammonia to its final concentration. Heat in the wastewater, discharged from the bottom of the column, is recovered by preheating the feed to the column.

principal advantages/disadvantages

- effective on concentrated streams
- high capital and operating costs
- complex equipment
- not employed in the Industrial Minerals or Metal Mining sectors

4.5 PHENOLICS

Potential

- natural degradation
- chemical oxidation
- biological oxidation
- carbon adsorption

Natural degradation (potential)

Aeration in ponds or lagoons which provide extended retention time can result in limited phenol removal. Forced aeration is generally more effective in reducing phenol levels than is passive aeration. The mechanism for phenol removal is not well understood, but likely includes simple air stripping and degradation by biological action, possibly assisted by ultraviolet light.

Chemical Oxidation (potential)

Chemical oxidizing agents, such as chlorine dioxide, hydrogen peroxide, ozone and potassium permanganate, will react with the aromatic ring of phenolic compounds resulting in its cleavage. This cleavage produces a straight chain organic compound which can be converted to carbon dioxide and water by additional chemical oxidation, or by other treatment such as biological oxidation.

Biological Oxidation (potential)

Phenols can be biologically oxidized under aerobic conditions using heterotrophic bacteria that break down or hydrolyse organic ring compounds. Once the ring configuration is broken, the resulting straight chain hydrocarbon would be further broken down to carbon dioxide and water by bacterial activities to remove the organic matter from solution.

Carbon Adsorption (potential)

Phenolic compounds in waste water are readily removed by contact with activated carbon. The carbon adsorbs many other organic compounds and must be regenerated or replaced when saturated.

principal advantages/disadvantages of the above technologies

- none of the potential treatments identified in this section have been employed for phenolics alone in the Industrial Minerals or Metal Mining sectors
- chemical treatment implies high capital and operating costs
- natural degradation (aeration) is limited in many applications by winter conditions

4.6 DISSOLVED SOLIDS

Potential

- chemical precipitation
- ion exchange
- reverse osmosis
- electrodialysis

Chemical Precipitation (potential)

Various chemical reagents can be added to waste waters to precipitate dissolved species as insoluble compounds. This technique is commonly used for the precipitation of heavy metal cations. The metals can be precipitated as hydroxides, sulphates or carbonates. The dissolved species are sometimes oxidized (e.g. ferrous to ferric) or reduced (e.g. chromic to chromous) prior to precipitation. Effectiveness is limited by solubility of the precipitated species and chemical reaction rate.

Ion Exchange (potential)

As dissolved solids are generally present as positive and negative ions in solution, ion exchange processes use both cationic and anionic resins to remove the dissolved solids from the waste water. In typical processes, the cation exchanger replaces the dissolved positive ion with hydrogen ions while the anionic exchanger replaces negative ions with hydroxide ions. This process is most commonly used for

removing dissolved salts from solutions having TDS (total dissolved solids) concentrations of less than 500 mg/L.

Reverse Osmosis (potential)

In reverse osmosis, waste water is pumped under high pressure over the surface of a membrane. Relatively pure water passes through the membrane, leaving dissolved solids behind in the concentrated reject. Pump pressures to effect the separation depend on the concentration of the dissolved solids in the wastewater and the desired flow rate of product per unit area of the membrane.

The main factors which dictate the suitability of reverse osmosis in a particular application for the removal of dissolved solids are:

1) the product water quality required
2) the water recovery desired (ie. fraction of total volume to be treated)
3) the ability to maintain the desired product flow.

Reverse osmosis has found its widest application in the production of potable water from sea water and brackish water.

Electrodialysis (potential)

In electrodialysis, feedwater is pumped into compartments separated by cation selective and anion selective membranes arranged in an alternating fashion. Under the influence of an electrical potential, cations pass through the cation selective membrane into the adjacent compartment. Further passage of cations is prevented since the next membrane is anion selective. Similarly, anions migrate towards the anode via the anion selective membrane. Further passage is prevented by the presence of a cation selective membrane at the end of the next compartment. This results in the depletion of dissolved salts in one process stream and the concentration in the other stream.

The main factors which dictate the suitability of this removal method for a particular application include:

1) product water quality required
2) water recovery desired
3) the ability to maintain the desired product flow

The main application of electrodialysis is in the production of potable water from brackish water.

principal advantages/disadvantages of above technologies

- none of the technologies are in use in the Industrial Minerals sector

- high capital and operating costs
- most of the described technologies are in use for treatment of comparatively small flows
- all of these technologies produce a concentrated stream containing the original TDS compounds which must be disposed of by other means

SECTION 5.

EFFLUENT QUALITY STANDARDS AND REGULATIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

5. EFFLUENT QUALITY STANDARDS AND REGULATIONS

Regulatory limits applicable to the Non-Metallic Mineral Division in Canada, the United States and Europe are generally confined to pH and suspended solids, and less commonly to oil and grease. For a large number of individual operations in both North America and Europe, limits have not been applied. This is partly because of the age and small size of certain operations, and also because of varying administrative practices at the local (province/state) level.

5.1 CANADA - FEDERAL REGULATIONS

Although there are general provisions within the Fisheries Act prohibiting the 'deposit of a deleterious substance of any type in water frequented by fish', there are no federal regulations or guidelines for effluent limitations which apply to the Industrial Mineral Sector.

5.2 CANADA - PROVINCIAL REGULATIONS

Ontario

The province has jurisdiction over water supplies and discharges under the Ontario Water Resources Act (OWRA), the Environmental Protection Act, and other pertinent legislation. The OWRA prohibits the discharge of any material that may impair the quality of water of any well, lake, river, pond, spring, stream, reservoir or other watercourse.

Primary control of non-metallic mineral effluents in Ontario is currently on a case by case basis through Certificates of Approval. The 1981 'Guidelines for Environmental Control in the Ontario Mineral Industry' have been used as a basis for determining limits. Effluent limits which are more stringent than these guidelines may be employed at newer operations. Limits at certain operations may also be set in order to meet Provincial Water Quality Objectives in the receiving water. The following limits are taken from the Guidelines for Environmental Control in the Ontario Mineral Industry:

pH	5.5 - 10.5
suspended solids	15 mg/L *

*This limit is commonly presented in Certificates of Approval as a monthly mean. Earlier permits presented the limit as a mean of four consecutive readings.

Quebec

A Certificate of Authorization is required by all operations. The discharge limits specified within this Certificate are determined on a case by case basis. Guidelines, defined in Directive 019 - Mining Industries, are used by the Quebec Ministry of the Environment as a basis for establishing individual site limits. In most instances, the limits set are the same as the guidelines. Relevant effluent discharge criteria outlined in Directive 019 are as follows:

pH	6.5 - 9.5
Total suspended solids	25.0 mg/L

New Brunswick

Under the Water Quality Regulation of the New Brunswick Clean Environment Act, any operation which discharges a contaminant to the environment is required to obtain a 'Certificate of Approval to Operate'. In practice, and for various reasons, few operations appear to possess a Certificate of Approval. Effluent discharges are typically only regulated if there is a disturbance to a fisheries habitat downstream. A limit of 25 mg/L for total suspended solids is used internally by the New Brunswick Ministry of the Environment.

Manitoba

All operations which discharge process water require a licence under the Environment Act. Effluent limits specified in the licence are primarily based on the federal Metal Mining Liquid Effluent Regulations and Guidelines. Limits are calculated from the Manitoba Surface Water Quality Objectives (July 1988) when more stringent standards are required to protect downstream uses. Applicable effluent discharge criteria from the federal guidelines are as follows:

Parameter	Maximum monthly mean	Maximum composite sample	Maximum grab sample
Total suspended solids (mg/L)	25.0	37.5	50.0

Parameter	Minimum monthly mean	Minimum composite sample	Minimum grab sample
pH	6.0	5.5	5.0

Nova Scotia

All mining operations require an industrial permit under the Nova Scotia Environmental Protection Act. The permit specifies limits for effluent discharge, which are normally based on the federal Metal Mining Liquid Effluent Regulations and Guidelines and as dictated by baseline information generated for the site. Typical limits for total suspended solids within the non-metallic mineral sector are 50 mg/L for a grab sample and 25 mg/L for a monthly mean.

Newfoundland and Labrador

Newfoundland and Labrador use the limits specified in the Environmental Control (Water and Sewage) Regulations to control the effluent discharges to sewer systems and open water. The following limits apply to discharges to open water:

pH	5.5 - 9.0
suspended solids	30 mg/L above background levels
oils (ether extract)	15 mg/L

Saskatchewan

Saskatchewan's 'Mineral Industry Environmental Protection Regulations' were created under the Environmental Management and Protection Act. All the non-metallic mineral plants require an Approval to Operate issued by Saskatchewan Environment and are governed under these regulations. The only limit provided in the regulations for the discharge of effluent is for pH, which should be between 6.0 and 9.5 in 75% of samples during any month, and should be between 5.0 and 10.0 for any one grab sample. Although not specified in the regulation, a total suspended solids level of between 25 and 50 mg/L is normally used by Saskatchewan Environment as a guide.

British Columbia

The Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia were formed under the Pollution Control Act. Discharges to water are controlled in the form of receiving water control objectives and objectives for the discharge of final effluents to marine and fresh waters. Operations which discharge process water are required to obtain a Waste Management Permit from the

British Columbia Ministry of the Environment. Limits are set on a case by case basis using the Pollution Control Objectives as a guide. The following limits are the objectives for the discharge of final effluents to marine and fresh waters:

pH	6.5-8.5 (fresh) - 6.5-10 (marine)
total suspended solids	25 - 75 mg/L
oil and grease	10.0 - 15.0 mg/L

<u>Alberta</u>

A licence to operate, issued by Alberta Environment, is required for all operations under the Clean Water Act of Alberta. Effluent limitations are specified within this permit. Although operations are reviewed on a site specific basis, the following guidelines generally apply:

All Non-Metallic Mineral Operations		
	pH	6.0 - 9.5
Cement		
	total suspended solids	35 mg/L
	chemical oxygen demand (COD)	50 mg/L
	oil and grease	5 mg/L
Salt		
daily basis:		
	total suspended solids	2 kg/tonne salt produced
	sodium	25 kg/tonne salt produced
	chloride	35 kg/tonne salt produced
monthly mean:		
	total suspended solids	1 kg/tonne salt produced
	sodium	7 kg/tonne salt produced
	chloride	5 kg/tonne salt produced

5.3 UNITED STATES - FEDERAL REGULATIONS

The 1979 US Development Document for Effluent Limitations Guidelines and Standards specified recommended discharge levels for non-metallic mineral producers based on Best Practical Control Technology Currently Available (BPCTCA), Best Available Technology Economically Achievable (BATEA) and New Source Performance Standards (NSPS) (Tables 5-1 and 5-2). Other than for graphite, gypsum and cement, the recommended standards have not as yet been adopted into regulation.

TABLE 5-1
EFFLUENT LIMITATIONS, GUIDELINES AND STANDARDS

Category	pH	Suspended Solids BPCTCA Maximum Monthly Average	Suspended Solids BPCTCA Daily Average	Suspended Solids BATEA - NSPS Maximum Monthly Average	Suspended Solids BATEA - NSPS Daily Average
Graphite (mg/L)	6 - 9	10	20	10	20
Gypsum - process water	6 - 9	zero discharge		zero discharge	
Gypsum - mine water (mg/L)	6 - 9	30		30	
Talc (dry) (kg/kkg product)	6 - 9	.5	1.0	3	.6
Salt - mine water (kg/kkg product)	6 - 9	.02	.04	.002	.004
Salt - salt pile run-off	6 - 9			zero discharge	

Table 5-2 summarizes the limits or guidelines applied to non-metallic mineral operations. The table is provided for comparison purposes only, since limits and guidelines are not equivalent in implementation.

TABLE 5-2
EFFLUENT GUIDELINES AND STANDARDS

Category	BPCTCA (Daily Maximum)	NSPS
Non Leaching		
TSS - kg/kkg product	0.005	0.005
Temperature (heat)	not to exceed 3° C rise above inlet temperature	not to exceed 3° C rise above inlet temperature
pH	6.0 - 9.0	6.0 - 9.0
Material Storage Piles Runoff (10 year 24 hour rainfall event)		
TSS - mg/L		50
pH		6.0 - 9.0

Current minimum federal effluent limits for the non-metallic mining category are designated by the Environmental Protection Agency (EPA) in the Code of Federal Regulations Title 40, part 411 and 436 (1989). Any operation which discharges process water to receiving waters is required to obtain a National Pollution Discharge Elimination System Permit (NPDES permit) issued by the Regional Administrator. Certain States also have the authority to issue NPDES permits. The Regional Administrator and authorized States have the power to specify more or less stringent criteria within the permit. Categories which are not included in the Code namely: cement, lime, salt, and talc are assessed on a case by case basis.

The reasons for not adopting the recommended standards (1979 US Development Document) into the 1989 Code of Federal Regulation are not entirely clear, but appear to be related to: (1) a lack of immediate concern to control pollutants from non-offensive industries, (2) difficulties in expressing suspended solids loadings as a function of production rates rather than as concentrations, for certain industries such as talc producers, and (3) possible technological/cost limitations.

Effluent limits adopted in the Regulation (Code of Federal Regulations Title 40, part 411 and 436, 1989) for the applicable non-metallic mining categories are based on the degree of effluent reduction attainable by the 'Best Practical Control Technology Currently Available '. If an operator feels that factors relating to the operation are fundamentally different from those specified in the Development Document, evidence may be submitted with a request to the Regional Administrator or the State (if the State has authority to issue NPDES permits) to have alternative limits established within their NPDES Permit. If the Regional Administrator (or State) approves new limits for the operation, the limits will be established based on the degree of difference between the factors involved. New limits must ultimately be approved by the Administrator of the Environmental Protection Agency.

Recommended limits from the US Development Document and limits specified in the Code (1989) are outlined in Tables 5-1 and 5-2.

Saline effluent discharges from salt mining operations are primarily monitored by the US EPA, but may be controlled in conjunction with the State. Permits are issued on a case by case basis and may regulate one or more of the following parameters: total dissolved solids (TDS), chlorides (Cl), total suspended solids (TSS), total flow and temperature. The criteria used to set limits vary from operation to operation, and may consist of maximum or net (the difference between background and discharge levels) limits as demonstrated by typical permit requirements for the following examples of plants in the United States:

Condensate Discharge:

plant 1	maximum	250 ppm Cl
plant 2	maximum	1,500 ppm TDS
plant 3	net	352 ppm Cl

The 1979 US Development Document for Effluent Limitations Guidelines and Standards recommended the following levels for salt producers based on BATEA:

Salt Pile Run-Off:	zero discharge

Process Wastewater and Mine Dewatering:

Total Suspended Solids (TSS)	0.002 kg/kkg of product (maximum average for 30 consecutive days)
	0.004 kg/kkg of product (maximum for one day)

It should be noted, however, that these criteria are not currently included in the Code of Federal Regulations.

United States - State Regulations

Certain individual states (including Texas, Michigan, and New York) which meet EPA requirements have been given the authority to enforce effluent quality standards. Limits in the permits may be more or less stringent than Federal standards. In the majority of cases the limits are more stringent.

5.4 EUROPE

The Commission of the European Communities is currently undertaking studies for the purpose of developing standard effluent limits across Europe by 1992. Until that time, each European country will continue to follow its existing effluent limits.

Germany

All industries in Germany are governed by the 'Federal Minimum Effluent Guidelines to the Receiver'. This regulation requires all operations to obtain a 'Water Authorization Permit' from their applicable regional authority. Effluent discharge limits are determined within the permit on a case by case basis and are dependant upon the water quality and size of the receiving water. The limits must also be less than those specified in any of the applicable guidelines. In the case of the non-metallic mineral sector, chemical lime

operations are restricted to a maximum suspended solid level of 100 mg/L under the draft Rock and Soil Industry Guidelines.

France

The Mining Code is the regulation which governs mining operations in France. Operations which involve on-site processing, notably cement and chemical lime plants, are regulated under the 'Law for Classified Installations'. Both of these regulations require that all operations obtain an 'Authorization' to operate. Authorizations may be acquired from the appropriate district (France is divided into over 100 districts). Limits specified within the Authorization are determined on a case by case basis. Although there are no published guidelines, the following criteria are used unofficially within the government:

pH	5 - 9
Suspended solids	30 mg/L

United Kingdom

Under the Water Act, any operation which discharges effluent to receiving water requires a 'Consent to Discharge'. Limits stipulated in the Consent are based on an assessment of the operation in question and are generally set in order not to exceed the 'Environmental Quality Standards' (EQS) of the receiving water.

Currently, the National Rivers Authority has control of all discharges to water bodies. During the next year 'Her Majesty's Inspectorate of Pollution'(HMIP) will be taking over responsibility for regulating effluent discharges. The system will be based on the 'Best Available Technology Not Excessive Costs' (BATNEEC).

5.5 SUMMARY - REGULATIONS

Following a review of legislation and guidelines with respect to the non-metallic mineral division, to date, specific limit regulations pertaining to all sub-sectors of the non-metallic mineral division have not been fully developed. Apart from some specific sub-sector applications in several jurisdictions, limits are associated with general guidelines covering all industrial operations or dischargers and/or mineral producers including metal mines.

The key parameters discussed with respect to regulations applied to the non-metallic minerals are pH, oil and grease and suspended solids. pH considerations are very similar under all jurisdictions with limits generally defined at a lower limit of 6.0 - 6.5 and an upper limit of 9-10.5. In comparison to the other jurisdictions reviewed, Ontario currently exhibits the greatest pH range from 5.5 -10.5.

Limits for oil and grease are less commonly defined but typically 10-15 mg/L for most jurisdictions. The most stringent limit directly applied to the cement sub-sector of industrial minerals is 5 mg/L in Alberta. Ontario's limit is 15 mg/L.

Ontario's Mineral Industry Effluent Guidelines incorporate the most stringent limits for suspended solids compared with all other jurisdictions reviewed. Table 5-3 provides the comparative limits currently legislated or proposed in Canadian, U.S. and overseas locations. These guidelines were developed with a greater focus and application to metal mines. The suspended solids concentrations have been minimized due to the expectation that the solids may be composed of contaminants such as heavy metals, which may further enhance the toxicity of the effluent. Suspended solids associated with non-metallic mineral operations are generally composed of inert rock and soil particles. As a result, the toxicity related to suspended solids within the non-metallic mineral industry may have greater flexibility with respect to the current limitation of 15 mg/L and in most cases, depending upon the sensitivity of receiving water, limits may more appropriately be defined by other jurisdictions as listed in Table 5-3.

Table 5-3 summarizes the limits or guidelines applied to Non-metallic Mineral operations. The table is provided for comparison purposes only, since limits and guidelines are not equivalent in implementation.

TABLE 5-3

COMPARATIVE REGULATORY LIMITS/GUIDELINES - SUSPENDED SOLIDS

Jurisdiction	Suspended Solids Limits/Guidelines (mg/L)
1) Ontario	15
2) Quebec	25
3) New Brunswick	25
4) Manitoba	25 (Monthly Mean)
5) Nova Scotia	25 (Monthly Mean)
6) Newfoundland/Labrador	30 (Above Background)
7) Saskatchewan	25-50
8) Alberta	35 (Cement Industry)
9) British Columbia	25-75
10) Canada	25 (Metal Mining)
11) United States (Federal)*	10 (Graphite only Monthly Average)
12) France	30
13) Germany	100 (Lime Industry)

* recommended limits from U.S. development document

SECTION 6.

SCREENING OF WORLD WIDE OPERATIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

6. SCREENING OF WORLD WIDE OPERATIONS

A compilation of non-metallic mineral operations within the primary countries of interest (Canada, United States, United Kingdom, France and Germany), was developed by means of various contacts and sources. These included the review of various industry publications and the use of personal contacts. Some of the key documents/contacts, and the countries they refer to, are listed below:

Canada:	Canadian Minerals Yearbook Canadian Mines Handbook Canadian Portland Cement Association
United States:	United States Portland Cement Association (and publications) United States Department of Labor (MSHA publications)
Worldwide:	Metals and Minerals Annual Review Mining Annual Review Industrial Minerals Directory

In addition, operations were also identified through contacts with government offices or embassies overseas, as well as industrial trade organizations.

The screening of Ontario, other Canadian, United States, and European non-metallic mineral operations is discussed below.

6.1 ONTARIO NON-METALLIC MINERAL OPERATIONS

A list of Ontario Non-Metallic Mineral producers was originally developed primarily by use of MISA documentation. These documents provided a comprehensive list of virtually all non-metallic mineral operations currently in production which discharge effluent off-site.

A questionnaire was developed for each of the non-metallic mineral categories. Topics addressed by the questionnaire included: methods of quarrying (mining), processing operations, water use / collection on site, sewage treatment, storage of materials, methods of water treatment and other pollution control on site. These questionnaires were sent to all Ontario non-metallic mineral operations, in order to obtain information which was not necessarily contained within the MISA initial reports.

This questionnaire was moderately well received, and several of the respondents included information beyond that which was requested. Follow-up phone calls encouraged response from some of the companies approached.

Simultaneous to the questionnaire survey, the study team reviewed the initial reports submitted under the MISA program by each non-metallic mineral direct discharger. An inventory sheet was completed for each operation based on the information provided in the initial report. A summary of effluent quality from each operation was also completed based on the twelve months of data (unedited) collected during the MISA program.

Where no response was received from the questionnaire (or where no questionnaire had previously been sent), the sites were contacted directly by telephone. A sheet was developed to assist in the collation of information by study team members during telephone discussions with site personnel. This collation sheet addressed: plant age/process technology age; mining and process technology; products and capacity; water use/reuse/recycle; waste water treatment; technical specifications; effluent quality.

Based on the review of MISA data, and responses to questionnaires, the effluent treatment system and its effectiveness was then evaluated. The study team then selected representative or unique operations from which to collect further information (either by telephone or site visit).

Visits were conducted to eleven sites in Ontario, encompassing eight of the non-metallic mineral categories. Two sites were visited within the cement, chemical lime and salt categories. These sites were chosen based upon several factors including: the quality of effluent currently being achieved; the wastewater treatment technology in use; and in some instances, the application of Best Management Practices during day-to-day operations. These visits should not be construed as defining the 'best plants' in Ontario, since the visits were for fact-finding purposes only.

The non-metallic mineral operations visited in Ontario are listed below:

Category	Company Name	Location
Cement	Lafarge Canada	Bath
	St. Marys Cement Company	St. Marys
Chemical Lime	Steetley Lime and Aggregates	Flamborough
	Stelco Chemical Lime Works	Ingersoll
Graphite	Cal Graphite Corporation	Kearney
Gypsum	CGC Limited	Hagersville
Nepheline Syenite	Unimin	Nephton
Basalt	3M	Havelock
Talc	Luzenac Inc.	Timmins
Salt	Canadian Salt Company (Windsor Salt)	Windsor
	Sifto Canada Inc.	Goderich

During the site visits, the operations kindly provided a tour of facilities, and detailed information beyond that which could be obtained through questionnaires, published documents, and telephone conversations.

6.2 OTHER CANADIAN NON-METALLIC MINERAL OPERATIONS

A list of plants outside of Ontario was generated from various sources, including industrial associations, the Canadian Minerals Yearbook, and other publications. Additional plant listings were provided by various provincial governments.

Selected operations throughout Canada were contacted for the purpose of inventory development. The operations were chosen based upon a variety of factors including whether the operations could be considered 'sister plants' to Ontario operations. The choice of operations was also based upon Kilborn and EAG's experience and knowledge of Canadian operations (including that of branch offices and related companies), as well as a review of relevant publications and discussions with various individuals and companies.

These selected operations were either requested to complete a questionnaire similar to that sent to Ontario producers, or were contacted directly by telephone. If contacted directly, an inventory sheet was filled out by the study team member during telephone discussions.

Since Ontario is the largest non-metallic mineral producer in Canada, the focus was placed upon Ontario producers. Operations were contacted within all other provinces although response rate varied. A number of non-metallic mineral operations located in the Prairie Provinces were contacted as well to a lesser extent operations in British Columbia and eastern Canada. No operations were contacted within the northern Territories due to the difference in climate, and the lack of non-metallic mineral production.

6.3 UNITED STATES NON-METALLIC MINERAL OPERATIONS

Non-metallic mineral operations in the United States were identified using the Industrial Minerals Directory, contacts with relevant Associations and a listing compiled by the United States Department of Labour, Mine Safety and Health Administration (MSHA). The listing includes all mines and non-metallic mineral producers currently active, along with their addresses, and average number of workers; while the Directory provides a list and brief description of all non-metallic, non-fuel mineral producers.

Due to the large number of non-metallic mineral operations, only a limited number of operations were contacted. These operations were selected primarily on the basis of their location, and the number of employees. The assumption is that locations with a negative water balance (ie. generally southern and western locations), and those with a small number of employees, would be unlikely to require, or have the capital funds available to employ either state-of-the-art or any other wastewater treatment technology. In general, southern and western operations have the opportunity to operate with 'zero volume discharge', taking advantage of high evaporation potentials relative to precipitation.

After the sites were selected, questionnaires similar to those used in Canada were mailed. Due to the very poor response rate from the United States, a selection of the sites initially contacted and sites not previously contacted were approached directly by telephone. As with the Canadian producers, a study team member completed an inventory sheet during these discussions. A large number of the operations contacted directly refused to comment, or offered to provide only a limited amount of information. As a result, the inventories of United States non-metallic mineral operations are less detailed than those of Canadian operations. Water quality data was acquired for selected sites through a U.S. consulting firm, retained for their experience and access to U.S. data/documents.

The aim in contacting United States operations was to obtain an overview of current water treatment technologies, rather than to contact every site. Those operations which were contacted by telephone were asked if they knew of more sophisticated treatment technologies, however, no new technologies were found by this method.

6.4 EUROPEAN OPERATIONS

European contacts were restricted to 'western' Europe, and focused primarily on Germany, France, and the United Kingdom. These areas are broadly similar to Ontario in terms of technological development, environmental awareness, and climate. Contacts outside of these major producing areas were not attempted, principally because there is little evidence to suggest that the pollution control technologies employed would be likely to represent an advance over other areas contacted. Obtaining information from eastern Europe in any case, is difficult at best. Only limited contacts were made with Scandinavian countries because, for the most part, (and with some notable exceptions), the geology of these countries does not particularly lend itself to non-metallic mineral production.

Initial contact was made with the foreign embassies of various countries in western Europe in order to receive information on the status of non-metallic mineral production within their respective countries. Individual companies in each country were then contacted by means of either information obtained through embassy contacts, or from the Industrial Mineral Directory. As with companies contacted in other areas of the world, questionnaires were completed either by plant personnel, or by the study team members during discussions with site personnel. These questionnaires provided the information for the inventory of wastewater treatment technologies.

Unfortunately, communication difficulties and a general lack of interest by international contacts, impeded the collection of information from overseas operations. Operations were not always cooperative, or could not see that they would benefit in any way by assisting in the study.

In order to develop a better understanding of some of the unique water treatment technologies in use in Europe for the treatment of suspended solids, a selected number of European sites were visited. Although only one of the sites visited was an non-metallic mineral producer, the remainder being in the Aggregates Division, the information obtained was of value to an assessment of the Non-Metallic Mineral Division.

SECTION 7.

INVENTORY OF SELECTED PLANT OPERATIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

7. INVENTORY OF SELECTED PLANT OPERATIONS

This section provides a summary of the processing and effluent treatment technologies currently employed within the various non-metallic mineral sectors. The focus has been placed on Ontario operations, however, information has also been obtained where possible, from other Canadian, United States, and European operations.

At operations which were receptive, general information could be obtained regarding the mining /quarrying and processing techniques, as well as the method of effluent treatment. Outside of Ontario, only rarely could information be obtained regarding the specifics of the effluent system, or the levels achieved. This information was either not available at the site, could not be released to consultants, or in the case of the effluent quality, had not been tested. At none of the operations contacted outside of Ontario was information available regarding the toxicity of the effluent.

The inventory summaries (Table 7-1) provide information regarding specific sites. Most sites are not identified specifically, due to a preference from the operations to remain unnamed.

7.1 CURRENT PRODUCERS

Cement

There are seven Portland cement producers in Ontario. Of these, six produce grey cement, with minor quantities of masonry cement; and one produces a small quantity of specialty white cement (Federal White). Most plants have on-site quarries.

Water used in the production of cement generally evaporates, and therefore does not require treatment. The exception to this is non-contact cooling water used to cool cement, as well as various pieces of equipment. The cooling water is generally once-through, and is typically not kept separate from plant site runoff. As a result, 'uncontaminated' cooling water may become contaminated with elevated levels of suspended solids, pH, and oil and grease from surface runoff. The cement plant effluent is generally treated in a settling pond prior to release.

In the case of white Portland cement, the clinker is made from iron-free materials and quenched in a water spray to ensure that any iron present remains in the ferrous state (and therefore avoids colouration by ferric iron compounds). Due to the process employed and the small quantity of cement produced, this operation (Federal White) is able to recycle all water used.

Quarry effluent, as distinguished from process plant effluent, is neutral to alkaline and has an increased concentration of suspended solids. Settling of solids in either sumps or ponds is used prior to release.

There are a total of 21 other Portland cement producers in Canada. Of the operations from which information was obtained, all produce cement by the same method, and where applicable, treat their effluents in the same manner. At all sites where the process effluent is treated, settling pond(s) are used. Similarly, quarry water is collected in sumps, and either released directly, or settled in ponds prior to discharge.

Information collected from individual sites, and discussions with various contacts in the United States suggests that processing and effluent treatment technologies used in the United States are the same as those currently in place in Ontario. At sites where wet processing is still occurring, a large proportion of the cooling water is recycled to process.

Discussions with cement producers in Europe indicate that the processing methods and treatment technologies in place, are equivalent to those used by Ontario producers. Unfortunately, the European plants contacted were not receptive to divulging site-specific information, and as a result, no inventories were completed for European producers.

Chemical Lime

There are six plants in Ontario which produce chemical lime, primarily for use in steel manufacturing. During the manufacturing of lime, the majority of the water used is evaporated. The major source of plant effluent is once-through non-contact cooling water, and scrubber water if wet scrubbers are used. Generally surface water from the plant area is not kept separate from the process effluent. Treatment of the effluent varies, however, it usually involves settling in ponds, with or without pH control. Process water is commonly drawn from the settling ponds and sumps.

Quarry water associated with lime plants is treated in a method similar to that of cement- captive quarries. Drainage is collected by means of sumps and treated for suspended solids either in the sumps themselves, or by pumping water to a settling pond.

Of the Canadian lime plants outside of Ontario from which information was obtained, all plants produce lime using the same method as employed in Ontario, and treat their effluent in the same manner. Process effluent is treated using settling pond(s) with or without pH regulation, while quarry water was collected in sumps, and either released directly, or into settling in ponds prior to discharge. The information available suggests that, in general, the settling ponds in use at locations outside of Ontario, are comparatively smaller in volume for similar sized operations, and appear to have a lower retention time.

Based on limited data which was available for U.S. lime plants, the effluent is treated in a manner similar to that in Ontario, although the sites contacted within the U.S. place more emphasis on separation of different effluent streams during treatment.

A similar process is used in Finland to produce chemical lime. The primary difference is that the source limestone is drawn from an underground mine rather than a quarry. The mine water is not treated prior to discharge.

Magnesium

In Ontario, Timminco produces high purity magnesium (99.95% pure) using the Pidgeon process, which appears to be unique to this operation. In this process, calcined dolomite/magnesite is reduced by ferrosilicon in a vacuum retort.

At this operation, both the magnesium plant effluent (primarily non-contact cooling water) and quarry water are released to the environment without significant treatment.

Although there are two other plants in Canada which produce magnesium; one in each of Quebec, and Alberta, there are no known 'sister plants' in Canada. The Quebec plant at Becancour produces magnesium from scrap; while the plant at Aldersyde Alberta produces magnesium from magnesite ore.

United States, which is the world's largest magnesium producer, has three major operating plants. These plants produce magnesium from: a seawater/dolomite process at Freeport, Texas; an electrolytic process at Rowley, Utah; and a Magnetherm process at Maddy, Washington. These plants can not be considered 'sister plants', and as a result were not contacted.

Published information on other producers of magnesium worldwide suggest that there may not be any 'sister plants' because of the process in use, and purity of the magnesium obtained by Timminco. Other

methods used in Europe include: electrolysis of seawater/dolomite employed at Porsgrunn, Norway; and the Magnetherm proprietary process in use at Marignac, France. Locations where plants are currently under various stages of development include: Norway, where the use of Brasmag technology is planned; Australia and India.

Graphite

Cal Graphite Corporation, located in Kearney near Huntsville, is the only currently operating natural graphite producer in Ontario. There are two effluent streams from the process plant: flotation tailings and filtrate from de-watering. These streams are collected and treated in a tailings pond. Passive filtration occurs as water seeps through a pervious dam to a polishing pond for further treatment. Run-off from storage piles of broken and crushed rock and mine water also drain to the tailings pond. Cal Graphite is expected to begin recycling water from the polishing pond shortly.

Passive filtration through the engineered tailings dam is accomplished through placement of coarse sand as an upstream facing on the waste rock dam core. Some slumping of the sand facing occurs from time to time, and plans are underway to stabilize the facing with geotextile, as required.

The two other Canadian graphite producers, outside Ontario, are located in Quebec, near Mont-Laurier. The producers, Stratmin Incorporated of Montreal and Ressources Graphicor (presently closed) both operate open pit mines. The graphite process and process effluent treatment at Stratmin Inc. are quite similar to that of Cal Graphite, in which a tailings pond and polishing pond are also used to treat process waste water. Run-off from the site, however, is not collected for treatment.

There are no known natural graphite producers in the United States, although there are several synthetic graphite producers located in various states. These producers were not contacted for this study, since they were not regarded as 'sister plants'.

Germany and Norway are the only European countries that produce substantial quantities of natural graphite. These two countries had a combined production of 17 000 tonnes or 2.5 % of the world production in 1990, while Canada's production was 1.3 %. Skaland Grafitverk is the only graphite producer operating in Norway. Graphite at this location is mined underground and upgraded by a flotation process using a frother but no collector. Tailings are dewatered in a thickener, from which the solution is recycled to the process and underflow slurry is discharged to a fjord.

Graphitwerk Kropfmühl AG, the only known graphite producer in Germany, extracts natural crystalline graphite from an underground mine located in Kropfmühl near Passau. The graphite ore is processed at one of two mills, located at the mine site and at Werk Wedel, Holstein. Processing is by flotation, similar to Ontario's producer, although additional chemical and heat treatment is employed at the Kropfmühl plant, in order to produce graphite in a range of grades with varying carbon content and fineness. At both locations, plants produce tailings wastes which are treated in non-engineered tailings/settling ponds.

Gypsum

Three companies produce gypsum from natural sources in Ontario: CGC Inc. operates a mine and wallboard plant in Hagersville; Domtar operates a mine and two wallboard plants in Caledonia, and Westroc Industries operates a mine in Drumbo and a wallboard plant off-site.

Domtar and Westroc Industries operate only dry crushing facilities to feed their wallboard processing facilities. The majority of water used in Domtar's wallboard manufacturing facilities is evaporated as steam with a small quantity remaining in the wallboard product. The only source of effluent at these two operations is mine water from underground operations. Both companies pump mine water from underground sumps to surface waters for discharge without additional treatment. Some mine water at Domtar is recycled for use in the wallboard process.

CGC Inc. is the only Ontario producer employing a heavy media separation process to produce gypsum. Gypsum ore is extracted from an underground mine and is processed by crushing, grinding, heavy media separation and de-watering, prior to being fed to the wallboard plant. Mine water pumped from underground sumps and process tailings are treated in separate mine water and tailings ponds. Two tailings ponds are employed in alternate service to allow periodic recovery of settled solids which are returned to the process. The overflow from these ponds combines in a ditch system and is discharged via a wetland. Trout are stocked in the mine water ponds.

Outside of Ontario, there are ten Canadian gypsum producers all of which extract gypsum from open pits. Producers in British Columbia and Manitoba employ primary crushing at the site and then transport the crushed gypsum offsite. The Atlantic region operators produce approximately 75% of Canada's gypsum and are the major Canadian exporters. Processing at these operations involves only crushing and screening.

Four of the ten gypsum pits in Canada have excess quarry water. Two producers collect the water in sumps and discharge to surface waters. The other two producers pump quarry water to a primary settling pond, which overflows to a polishing pond prior to discharge.

Only one Canadian producer (outside of Ontario) utilizes a wet process. In Nova Scotia, the Fundy Gypsum Co. Ltd. produces anhydrite which is crushed and washed prior to shipment. Wash water is used in a closed circuit of two ponds with only a small bleed being released to the environment.

Of the five major gypsum producers contacted in the United States, only one operates an open pit. The producers utilize dry crushing and grinding to provide feed to their wallboard plants. Mine and quarry water are collected at all sites and discharged directly to the environment. One operation also produces a process effluent from their plaster process which is collected in a settling pond. A large portion of water is recycled from this pond, the remainder being discharged.

Three companies in the United Kingdom, France and Germany dominate the European gypsum market. British Gypsum in the United Kingdom, extracts gypsum from open pits and underground mines with very little water use. Mine water is collected in a settling pond prior to discharge to the environment. Knauf Westdeutsche Gipswerke in Germany, has similar operations with very little mine water which is also pumped to settling ponds and then released.

Nepheline Syenite

Unimin Canada Ltd. operates two plants which produce various grades of nepheline syenite from a single open pit operation at Havelock, Ontario. The cooling water and tailings slurry are discharged to a tailings pond for treatment, with a flocculant is added in-line to improve settling efficiency. Effluent from the tailings pond is decanted to a clarification pond prior to release as required. Plans are in place to initiate recycling of water from the clarification pond to the process.

The only other producing plant known to the study team is located in Norway. This plant produces approximately half the amount of nepheline syenite as the Ontario plants, using a similar method. Dry rejects from the plant are disposed directly into a fjord with no treatment. There is a very small amount of water used for dust control within the process, but there is no effluent treatment.

Basalt

The only basalt quarry which is currently operating in Ontario is located in Havelock. The ore is mined from an open pit, crushed, screened, sized, and colour coated, for use in asphalt shingles.

The majority of the water used in the colouring plant is used for two purposes; as a liquifying agent to spread the clay-sodium silicate colour coating on the rock, and to cool the finished product. All water used in these processes is discharged as steam. The bulk of the water used in the crushing plant is for cooling of the crushing equipment.

All waste water from the colouring plant and crushing and screening plant is discharged into a series of two settling ponds, followed by a pumphouse pond from which water is recycled to the plant. Under normal conditions, there is a 100 % recycle of water to process, and the negative water balance is made up by a supply of fresh water.

The only net effluent consists of quarry water which is pumped to a small settling pond before being discharged to a wetland.

Talc

Ontario's two talc producers, Canada Talc Ltd. in Madoc, and Luzenac Inc. in Timmins, mine and process talc quite differently. Canada Talc Ltd. extracts talc ore from an underground mine and then the talc is crushed, pulverized, dried and bagged. The only effluent produced is mine water, which is discharged through a swampy area off-site.

Luzenac Inc. extracts talc ore from an open pit. After crushing and wet grinding the talc is upgraded using flotation, magnetic separation and filtration. Flotation tailings are pumped to a tailings pond from where effluent seeps through a barrier of crushed rock to a settling pond, from which it is discharged to a wetland. Quarry water is collected in a separate settling pond which also discharges to a wetland.

Within the Non-Metallic Minerals Division, the Ontario talc operations are unique in that their effluent contains arsenic, although the levels present are below the Provincial Water Quality Objective of 0.1 mg/L.

The two other Canadian talc producers Luzenac Inc. in St. Pierre de Broughton, and Bakertalc in South Bolton operate an open pit and underground mine, respectively, in Quebec. Processing at Luzenac includes dry crushing and grinding. There are no process or quarry water effluents at this site. At Bakertalc, talc is crushed and ground, upgraded by froth flotation, and then dried for final milling. Tailings from the flotation circuit are collected in a tailings pond, which overflows to a polishing pond prior to discharging to the environment. There is no mine water discharge.

The United States is the world's largest talc producing and exporting country, with New York, Vermont, Texas and Montana being the major producing states. Of these states, producers in Texas were not contacted due to climatic differences with Ontario. All producers contacted operate open pit quarries, although there are underground producers operating within the United States. Of the operations contacted, one producer operates an essentially dry process, utilizing only crushing, while the other producers employ flotation processes. Flotation tailings are collected in tailings ponds, with some of the clarified water recirculated to the process; the remaining water is discharged to the environment.

Talcs de Luzenac, the only talc producer in France, dominates the talc production in Europe. Located in the Pyrenees, this plant extracts a mixture of talc and chlorite ore from veins in an open pit. High purity talc is picked by hand. The remaining ore is optically sorted using laser techniques and then dried, ground, and micronised. By natural drainage and the use of ditches, quarry water flows by gravity to a parallel two basin system, followed by natural overflow to the environment.

Other smaller European talc producers are located in Finland, Norway and Sweden. At Myllykoski Oy in Finland, talc ore is extracted from an open pit and refined by flotation with 90% recycle of process water. Process effluent, drawn from the flotation process as a bleed, is collected in a series of two large settling ponds prior to discharge. As in Ontario, a small quantity of arsenic is present in the effluent.

Salt

There are two salt producers in Ontario: Windsor Salt, a division of the Canadian Salt Co., located in Ojibway near Windsor, and Sifto Salt located in Goderich. Both producers operate a rock salt mine and a solution mining/evaporation plant. Each producer's rock salt mine and evaporation plant are some distance apart and are therefore described separately.

Rock salt is mined underground by both producers and then crushed, screened and subsequently packaged or stored in bulk for shipping. At Windsor Salt, all processing is conducted on the surface, while processing at Sifto Salt is conducted underground. Rock salt mining is essentially dry although there is minor seepage from shafts, equipment washing, and condensation from ventilation air. Some of this water is sprayed on the underground roads for dust control while the remaining water is collected and pumped to surface for discharge. Wet scrubbers are used at one plant (Windsor Salt) to collect salt dust from the crushing and packaging areas on the surface and water is discharged after a once-through use.

Solution mining requires a great amount of water which is pumped into injection wells and withdrawn as a saturated brine solution from withdrawal wells. Salt crystals are then recovered from the brine solution by a 3- or 4- effect evaporation process at Windsor Salt and Sifto Salt, respectively. Evaporation bleed streams, condensate, condenser cooling water, spill washing and scrubber water are the primary sources of effluent from the evaporation process.

Effluents from rock mining and solution mining are typically high in dissolved chlorides of magnesium, calcium and sodium. Cost effective waste water treatment systems for such effluents presently do not exist, and reduction of high TDS effluents relies heavily on best management practices. The Sifto Salt evaporation plant in Goderich does, however, collect process effluent in a settling pond to settle precipitated gypsum and other suspended solids prior to discharge.

Of the five Canadian salt producers located outside Ontario, there are a total of two rock salt mines and three solution mines. The rock salt producers, Les Mines Seleine in Quebec and Canadian Salt Company in Nova Scotia, mine rock salt by methods similar to the Ontario operations. The rock salt mine in Nova Scotia is unique in that it utilizes a 4-effect evaporator operation to recover salt from a solution of dissolved rock salt fines.

A solution mining operation (Sifto Canada Inc.) is also located in Amherst, Nova Scotia. The two Nova Scotia operations (rock salt and solution mine) are located adjacent to a tidal river into which run-off and saline effluents are discharged.

Two other solution mining and evaporation plants are located in Unity, Saskatchewan (Sifto Canada Inc.) and Elk Point, Alberta (Windsor Salt). At these locations, non-saline water is discharged to rivers, and saline effluents are either recycled or directed to disposal wells. Salt in the western provinces is also produced as a by-product from potash processing. No information from these producers was obtained as these operations were not considered 'sister plants'.

Salt recovery in the United States is achieved through three methods: rock salt mining, solution mining, and solar evaporation. Solar evaporation plants were not contacted since the process is not applicable to Ontario's climate.

The rock salt and solution mining operations in Michigan, New York, Pennsylvania, Ohio and West Virginia are most comparable to the Ontario operations, although the evaporation plants differ in the number of evaporation effects utilized.

Generally, there is no treatment of the saline waste water associated with rock salt and solution mining in the U.S.. The management of various effluents from the solution mining and evaporation processes on-site varies from plant to plant. Most high salinity effluents are recycled back to the process while non-saline effluents such as condensate are discharged to the environment. The concentrations of chlorides in the brine solutions are site specific and therefore the capability of recycle is also site specific.

Germany and the United Kingdom are the major salt producers in Europe with a combined production of 11.5 % of world production in 1990. Information gathered from the European contacts indicates that salt recovery methods of rock salt mining and solution mining are similar to those employed by Ontario's salt producers. One rock salt mine in Germany, Sudwestdeutsche Salzwerke which was visited, recovers salt using a heavy media cyclone process followed by vacuum recrystallisation. There is no effluent released from this process since all water is recycled.

Generally, rock salt mining and processing is dry, with no water used underground. BHS in Germany crushes and stores all product salt underground until the time of loading for shipping, eliminating the problem of run-off. Process water from solution mining and evaporation is generally discharged to surface water without treatment.

Most of the European salt producers must apply for consent to discharge with site specific limits given for pH, suspended solids, temperature and flow. Only one German producer indicated that the chloride concentrations were regulated based on kilograms of chloride per tonne of product.

7.2 SUMMARY PERFORMANCE OF WASTE WATER TREATMENT FACILITIES

7.2.1 EFFLUENT QUALITY

Table 7-1 presented at the end of this section summarizes the waste water treatment technologies in use throughout Ontario, Canada, the United States and Europe, and their effluent performance data, where available. The effluent performance data for the Ontario non-metallic mineral producers was obtained from the Ontario MISA monitoring program in which water quality testing was performed over a period of one year, from August 1990 to July 1991. At the time of printing, only unedited monitoring data which had not undergone QA/QC assessment was available. As a result, although the trends within the monitoring data are likely correct, individual values listed in Table 7-1 may require amendment after final editing of data.

Performance of the treatment technologies may be evaluated from this monitoring program. Although many parameters were monitored in the MISA program, Table 7-1 focuses on 5 main parameters which include pH, suspended solids, oil and grease, phenolics and ammonia/ammonium which are presented as long term average (LTA) concentrations. Performance data for operations outside of Ontario will not be discussed because of a lack of information.

Waste water treatment employed in the Non-Metallic Mineral Division is directed almost solely at the control of suspended solids. Treatment technologies consist mainly of tailings and/or polishing ponds in series although some systems also include pH adjustment.

Cement

The effluent performance data for the various cement operations in Ontario indicate a range of concentrations of suspended solids from 11.5 mg/L to 231.9 mg/L. The pH of the waste waters are neutral to alkaline, with levels between 7.79 and 10.48. Concentrations of oil and grease average 1.2 mg/L, but can be as high as 4.28 mg/L. Phenolics are generally between 1.30 μg/L and 5.45 μg/L, with one reported case of 39.46 μg/L. Ammonia levels are usually below 0.59 mg/L, but one case was reported at 4.19 mg/L.

Chemical Lime

Waste water from chemical lime producers, is comprised mainly of non-contact cooling water, scrubber water, vehicle wash water and water for dust suppression. Suspended solids in the discharge from settling ponds, which treat the waste water, range from 7 mg/L to 54.5 mg/L. The water is alkaline, with pH ranging between 7.13 and 10.0. Oil and grease concentrations range from 1.0 mg/L to 2.37 mg/L. Phenolic concentrations are between 1.0 and 13.0 μg/L, with one reported case at a level of 252.1 μg/L, and ammonia levels generally range between 0.28 and 0.60 mg/L.

Magnesium

Effluent discharged from the one Ontario magnesium producer site has a suspended solids concentration averaging 6.9 mg/L; pH of 7.9; oil and grease concentration of 1 mg/L; phenolics concentration of 2.7 mg/L, and an ammonia/ammonium level of 6.2 mg/L.

Graphite

Water quality from the one Ontario graphite producer indicates a slightly acidic pH at 6.35. Suspended solids are at a level of 12.8 mg/L. Oil and grease concentration is at 1.63 mg/L, and phenolic were comparatively high, at 21.48 μg/L.

Gypsum

Waste water from gypsum producers is comprised mainly of mine water, with one producer releasing water from a flotation process. Discharges generally have a suspended solids level between 10.5 mg/L and 42.7 mg/L, although one case of 118.0 mg/L was reported. The slightly alkaline waters have an average pH of 7.8. Oil and grease levels range between 1.05 mg/L and 3.83 mg/L, with one concentration noted at 12.84 mg/L. Phenolic concentrations average approximately 1.2 μg/L, but can be as high as 35.75 μg/L. Ammonia levels range between 0.03 mg/L and 4.01 mg/L. Waste waters from two of the producers are also noted to be toxic to Daphnia magna based on preliminary data.

Basalt

The Ontario basalt producer discharges treated quarry water having the following characteristics: a suspended solids concentration of 9.0 mg/L, pH at 8.13, oil and grease concentration of 1.12 mg/L, a phenolic concentration of 0.47 μg/L and ammonia level of 0.8 mg/L.

Nepheline Syenite

Nepheline syenite in Ontario is produced by two plants from a single open pit operation. Waste waters from this pit are treated in a series of 2 ponds. The effluent has a suspended solids concentration of 47.1 mg/L, and a pH of 8.61. The concentration of oil and grease is 1.04 mg/L, phenolic is 4.88 μg/L and ammonia is 0.2 mg/L.

Talc

Waste water from talc producers is comprised of groundwater from either underground or open pit mining, as well as discharge of tailings effluent from a single producer. Suspended solids concentrations in the waste water range from 3.7 mg/L to 16.9 mg/L. The water is alkaline, with pH ranging between 8.12 and 8.68. Oil and grease is on average 1.0 mg/L. Phenolic concentrations are between 2.29 μg/L and 2.58 μg/L. Ammonia levels range from 0.03 mg/L to 1.00 mg/L. Unique to these producers is arsenic, which ranges between 8.2 μg/L and 82.2 μg/L in the effluents.

Salt

Waste waters from salt producers are comprised of mine water, scrubber water and water used in the solution mining and evaporation process. Waters are slightly alkaline having a pH ranging between 7.09 and 8.01. Suspended solids concentrations range from 13.4 mg/L to as high as 350 mg/L. Oil and grease levels are usually between 1.10 mg/L and 6.77 mg/L, but one case was reported at 249.0 mg/L. Phenolic concentrations are comparatively high and range from 3.75 μg/L to 22.76 μg/L. Ammonia

concentrations are between 0.14 mg/L and 6.41 mg/L. In addition to these parameters, chloride concentrations, unique to this industry, are reported for a range of 1 091 mg/L to 100 471 mg/L.

In general, there is little correlation between performance and the type of effluent treatment used. The wide range of concentrations of the priority parameters, between the individual non-metallic mineral producers, can be attributed to variations in site conditions, surface and ground water volume contribution, raw materials and the degree of water recycle. Many of the settling ponds used within the industry are non-engineered structures and have generally been developed without regard to pond sizing, particle settling characteristics, short circuiting and other factors.

7.2.2 Toxicity

Current toxicity information specific to non-metallic mineral operations is limited. Preliminary toxicity data compiled under the MISA program (see inventory sheets, Table 7-1) indicate that certain mineral categories have experienced toxic effluents, based on the LC50 test results for Daphnia magna (48 hours) and Rainbow Trout (96 hours).

TABLE 7-2
SUMMARY OF PRELIMINARY TOXICITY RESULTS

Category/Effluents tested	Number of Effluents Demonstrating Toxicity	
	Daphnia magna	Rainbow Trout
Cement (6)	3	3
Chemical Lime (6)	2	2
Magnesium (1)	0	0
Graphite (1)	0	0
Gypsum (3)	1	1
Nepheline Syenite (1)	1	1
Basalt (1)	0	0
Talc (2)	0	0
Salt (4) * 2 Rock Salt Operations 2 Brine Operations	4	4

* MISA considered these '4' operations as '2' plants
( ) Indicates total number of plants

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	RELATIVE CAPACITY	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - CEMENT IN ONTARIO																	
1. St. Marys Cement Corp.	St.Marys, Ont.	80	Open pit	Anfo blasting	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	medium	non-contact cooling, truck/vehicle wash	no	most cooling water untreated, some cooling water and site runoff through oil/water separators & settling in 2 ponds, quarry water collected in sumps	4834 m3/d, process	electrostatic precipitator baghouses on-site sewage treatment	YES, Daphnia	8.35	18.4	1.24	2.52	0.32
										8483 m3/d, quarry		YES, Daphnia	8.17	45.1	1.57	3.00	0.23
										194 m3/d, storm		-	8.32	116.5	1.40	1.79	0.06
										343 m3/d, storm		-	10.48	215.1	1.00	3.94	0.18
2. Lafarge Corp.	Bath, Ont.	18	Open pit	Anfo blasting	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	large	non-contact cooling	no	plant effluent collected in drains quarry water collected in pond	2959 m3/d, process	collection sump for coal pile run-off, no discharge. sewage lagoon	NO	8.30	11.5	1.17	1.30	0.06
										554 m3/d, quarry		YES, Trout	8.04	45.5	1.08	2.12	0.37
										864 m3/d, storm		-	8.20	32.0	1.50	1.00	0.13
3. Lafarge Corp.	Woodstock, Ont.	-	Open pit	blasting	1.blending feed (wet) 2.calcine 3.grind with gypsum	small	non-contact cooling, slurry formation	no	collection in settling pond, pumped to discharge ditch	598 m3/d, process	electrostatic precipitator	NO	8.29	231.9	4.28	3.10	0.01
										1610 m3/d, quarry		NO	8.27	102.9	1.43	2.52	0.38
4. Essroc Canada Inc.	Picton, Ont.	33	Open pit	Anfo blasting	1.blending feed 2.crushing 3.calcine 4.grind with gypsum	large	non-contact cooling, 19 145 m3/d	no	plant effluent drains through stormwater sewers, Mine water collected and pumped to lake	7104 m3/d, process	electrostatic precipitator	YES,	8.41	31.7	1.45	2.50	0.07
										2989 m3/d, quarry		YES, Daphnia, Trout	8.88	31.5	1.28	5.45	0.59
5. St. Marys Cement Corp.	Bowmanville, Ont.	23	Open pit	Anfo blasting	1.blending feed (wet) 2.calcine 3.grind with gypsum	large	non-contact cooling, slurry formation truck/vehicle wash	no	no plant effluent quarry water collected at base of quarry	3456 m3/d, process	truck wash diverted	YES,	8.25	115.2	1.33	3.03	0.08
										983 m3/d, quarry		YES, Daphnia, Trout	7.79	200.6	3.18	39.46	4.19
6. St. Lawrence Cement	Mississauga, Ont.	35	none	-	1.blending feed 2.crushing 3.calcine 4.grind with gypsum	large	non-contact cooling	no	collected in storm sewers	17 030 m3/d, process	electrostatic precipitator coal pile run-off collected and allowed to evaporate	NO	8.26	20.9	1.19	1.58	0.05
7. Federal White	Woodstock, Ont.	12	none	-	-	small (White Portland Cement Only)	non-contact cooling	100%	100% recycle of non-contact cooling water	0 m3/d	none	N/A	no discharge				

CAPACITY
Large: >1,000,000 tonnes/a
Medium: 500,000 to 1,000,000 tonnes/a
Small: < 500,000 tonnes/a

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	RELATIVE CAPACITY	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - CEMENT IN CANADA OUTSIDE OF ONTARIO																	
1.	Brookfield, Nova Scotia	26	Open pit	Anfo blasting	1.crushing 2.screening	small	non-contact cooling, 2 272 m3/d washing	-	settling in 3 ponds	-	electrostatic precipitator sewage-aerated lagoon	-	7.50	20.0	10.00		-
2.	Cornerbrook, Newfoundland	39	Open pit	Anfo blasting	1.crushing 2.screening	small	non-contact cooling, 363 m3/a	-	-	-	electrostatic precipitator	-	-	-	-	-	-
3.	Joliette, Quebec	25	Open pit	Anfo blasting	1.crushing	medium	non-contact cooling, dust supression	-	settling pond pH adjustment (H2SO4)	-	-	-	8.50	-	-	-	-
4.	Winnipeg, Manitoba	25	none	-	-	small	non-contact cooling	yes	settling pond discharge to storm sewer	-	sewage treatment plant	-	-	-	-	-	-
5.	Regina, Sask.	35	none	-	-	small	non-contact cooling, 11 m3/h	-	settling in 2 ponds	-	electrostatic precipitator sewage lagoon	-	-	-	-	-	-
6.	Cornerbrook, Newfoundland	26	Open pit	Nilite/ Tovan blasting	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	small	non-contact cooling, 26 m3/h truck/vehicle wash	no	settling pond								
7.	Exshaw, Alberta	80	none	Anfo blasting	1.crushing 2.grinding	large	non-contact cooling, electrostatic precipitator	no	oil/grease traps settling pond	2 300 m3/d	-	-	8.00	11.5	<10.0	-	-
8.	Edmonton Alberta	50	Open pit	Hydraulic backhoe	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	medium	non-contact cooling, 20 m3/h dust suppression washing	-	settling pond	-	-	-	8.50	15.0	1.00	-	-
9.	Delta B.C.	13	none	-	-	large	non-contact cooling, washing roads	-	none	-	electrostatic precipitator sewage treatment diffuser	-	-	-	-	-	-
10.	Richmond B.C.	32	none	-	1.blending feed (wet) 2.calcine 3.dry grind with gypsum	small	non-contact cooling	no	settling pond	-	electrostatic precipitator	-	-	-	-	-	-
11.	Kamloops B.C.	20	Open pit	Anfo blasting	1.crushing	small	non-contact cooling, 186 m3/h	no	-	-	electrostatic precipitator baghouse	-	-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	RELATIVE CAPACITY	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - CEMENT IN USA																	
1.	Louisville, Nebraska	62	Open pit	Anfo blasting	1.crushing 2.screening	medium	non-contact cooling, 45 m3/h truck/vehicle wash, 378 m3/d	-	none	-	electrostatic precipitator	-	7.50	45.0	10.00		-
2.	Charlevoix, Michigan	12	Open pit	Austin powder blasting	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	large	non-contact cooling, 8 to 11 m3/d	-	settling in 5 ponds non-contact cooling water discharged directly	38 000 to 49 000 m3/d	coal pile run-off collected and allowed to evaporate	-	-	-	-	-	-
3.	Speed, Indiana	18	Open pit	Anfo blasting	1.blending feed (dry) 2.crushing 3.calcine 4.grind with gypsum	medium	non-contact cooling, 20 000 m3/d	yes	storm pond for process water settling pond for clay pile settling pond for coal pile pH adjustment	-	electrostatic precipitator cyclones, scrubbers, baghouses	-	-	-	-	-	-
4.	Inkom, Indiana	40	Open pit	Anfo/ dynamite blasting	1.blending feed (wet) 2.calcine 3.dry grind with gypsum	small	non-contact cooling, 68 m3/h slurry formation, dust suppression	yes	no effluent due to evaporation and recycling	-	-	-	-	-	-	-	-
5.	Nazareth, Pennsylvania	-	Open pit	-	-	large	non-contact cooling	yes	2 sumps and 2 settling ponds in series	21 600 m3/d	storm water collected via underground drainage system to quarry	-	-	-	-	-	-
6.	Louisville, Kentucky	88	none	-	-	small	non-contact cooling, 3 785 m3/d limestone slurry, 635-725 t/d	yes	1 engineered settling pond	-	none	-	-	-	-	-	-
7.	Cape Girardeau, Missouri	-	Open pit	-	-	large	non-contact cooling	yes	non-contact cooling water, quarry water and run-off collected in clay pit, water evaporates and/or percolates through soil	0	none				no discharge		
8.	Hagerstown, Maryland	-	Open pit	-	-	medium	non-contact cooling	no	quarry water pumped to settling pond, non-contact cooling water and storm water collected in 5 in-ground catch basins	5830 m3/d 3105 m3/d	N.B. quarry water effluent includes some storm water and non-contact cooling water	- -	7.8-8.1 7.3-8.3	3-14 0-2	- -	- -	- -
9.	Glens Falls, New York	-	Open pit	-	-	medium	non-contact cooling	no	none	-	-	-	-	-	-	-	-
10.	Ravena, New York	-	Open pit	-	-	large	-	-	-	7 230 m3/d	-	-	7.70	20.1	1.04	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - LIME IN ONTARIO																
1. Steetley Lime	Dundas, Ont.	60	Open pit	Anfo blasting	1.crushing 2.clearstone burning in kiln	dust suppression washing stone non-contact cooling truck/vehicle wash dust collection from precipitators	yes	collection in sumps settling in 2 tailings ponds in-line pH adjustment CO2/H2SO4 discharge to final settling pond	8,825 m3/d	electrostatic precipitators baghouses	NO	7.13	11.2	1.44	2.00	0.60
2. Stelco Lime	Ingersoll Ont.	45	Open pit	Anfo blasting/ (gel if wet)	1.crushing 2.sized stone to kilns 3. crushing	dust suppression, occasional kiln fan cooling, ocassional non-contact cooling, 23-28 m3/h truck/vehicle wash, 3.4 m3/d, not in winter	yes	collection in sumps, discharged to ditch and settling pond	21,000 m3/d	electrostatic precipitators road dust suppressants	NO	8.06	7.0	1.06	1.10	0.33
3. Beachvilime East Plant	Beachville Ont.	60	Open pit	blasting	1.crushing 2.screening 3.partial feed to kilns	dust suppression, scrubber water non-contact cooling, truck/vehicle wash	yes	collection in sumps settling in 5 ponds pH adjustment H2SO4 in pond 3 discharge to final pond	21,087 m3/d	wet scrubber baghouses	YES Daphnia, Trout	8.72	23.8	1.17	13.00	0.33
4. Beachvilime West Plant	Beachville Ont.	80	Open pit	blasting	incl.above	dust suppression, non-contact cooling, truck/vehicle wash	yes	collection in settling ponds/ sump, discharge with quarry water	13,873 m3/d	-	NO	7.97	54.5	1.19	1.00	0.28
5. DoLime	Guelph Ont.	119	Open pit	blasting	1.crushing 2.screening 3.partial feed to kilns	hydrating process, dust suppression, scrubber water	yes	settling in 3 ponds	1,483 m3/d, process 6,252 m3/d, process	-	NO NO	7.67 7.97	8.4 23.4	1.00 1.10	1.50 1.00	0.29 0.37
6. Reiss Lime	Spragge Ont.	-	none	-	1.Imported stone to kilns 2.slag ground in press or ball mill	-	-	settling ponds	-	wet scrubber, 100 g/min	YES Daphnia, Trout	10.00	16.8	2.37	252.1	-
SUB-HEADING - LIME IN ONTARIO - not monitored under MISA																
7.	Haileybury Ont.	16	Open pit	Anfo Blasting	-	none	-	sump, occasional discharge	-	-		-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - LIME IN CANADA OUTSIDE OF ONTARIO																
1.	Fort Langley, B.C.	20	none	offsite	-	hydrating process, truck/vehicle wash, scrubber water, kiln cooling	yes	partial discharge to sewer partial discharge to 2 settling ponds	-	-	-	-	-	-	-	-
2.	Faulkner, Manitoba	16	Open pit	Anfo blasting	1.crushing 2.screening	scrubber water	yes	settling in 2 ponds (process water), mine water to lake	-	lignosulphate for dust control	-	8.00	-	-	-	-
3.	Exshaw, Alberta	24	none	offsite	1.grinding	hydrating process, scrubber water, 45 m3/h	yes	settling in 3 ponds, no discharge to environment due to evaporation	-	-	-	10-11		-	-	-
4.	Havelock, New Brunswick	46	none	offsite	-	washing, scrubber water	yes	settling in series of 2 ponds before recycle scrubber water returned to	-	-	-	-	-	-	-	-
SUB-HEADING - LIME IN USA																
1.	Carey, Ohio	90	Open pit	blasting	1.crushing 2.screening 3.partial feed to kilns 4.wash stone	hydrating process washing aggregate	-	seven settling ponds: 3 in series for process water, plus 2 in series, and 1 separate for quarry water, all feed into a single holding pond	11 400 m3/h	maintain separate effluent streams	-	7-9	5	-	-	-
2.	Woodville, Ohio	-	Open pit	blasting	-	-	-	stormwater, non-contact cooling water and quarry water to engineered settling pond, then discharged	not monitored	-	-	-	<detection limit	-	-	-
3.	Bellefonte, Pennsylvania	-	none	offsite	-	-	yes	settling pond with pH adjustment	-	none	-	-	-	-	-	-
4.	Clearbrook, Virginia	-	Open pit	blasting	-	wet scrubber	yes	process water recycles through two ponds back to process quarry water collects in sump and is discharged	0 45 m3/d	no process water discharged	- -	- -	- 3-4	- -	- -	- -
5.	Strasburg, Virginia	-	Open pit	-	-	-	no	water collected in quarry no discharge, water evaporates or percolates through soil	0	none				no discharge		
6.	Detroit, Michigan	-	none	offsite	-	-	-	no water discharged	0	none				no discharge		
7.	Millersville Ohio	-	Open pit	-	-	scrubber water, 227 m3/h cooling water, 45 m3/h	yes	process water settling in series of 5 pond, then recycled quarry water collects in sump and	0 908 m3/d	storm water collected in quarry via dikes and ditches	-	7.65	1.0	no discharge -	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - LIME IN USA (cont'd)																
8.	Huron, Ohio	-	none	offsite	-	-	yes	no discharge	0	none		no discharge				
9.	Hanover, Pennsylvania	-	Open pit	-	-	-	yes	3 settling ponds in series sumps in quarry	20 600 m3/d, quarry water	stormwater collects in quarry via ditches	-	8.50	30.5	-	-	-
												settling pond				
											-	8.20	14.5	-	-	-
												clarification pond (at discharge) (1 month data only)				
SUB-HEADING - LIME IN EUROPE																
1. Tytyr	Lohja, Finland	45	u/g	ANFO blasting	1.crushing 2.screening 3.calcining	hydrating process, non-contact cooling	yes	no waste process water mine water untreated	2,400 m3/d	effluent sold as raw water to town	-	-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - GYPSUM IN ONTARIO																
1. CGC Inc.	Hagersville, Ont.	-	u/g	Anfo blasting	1.crushing 2.grinding 3.heavy media separation 4.calcining	process water, 40 m3/h wallboard process water, 113 m3/h excess mine water	yes	mine water to 1 of 2 settling ponds, tailings to tailings pond, overflow to secondary pond	5499 m3/d, process 4007 m3/d, mine	run-off from piles etc. collected in ditches	NO YES, Trout	7.89 7.91	39.5 17.6	1.16 1.07	1.08 1.00	0.61 0.32
2.Domtar	Caledonia, Ont.	-	3 u/g mines	cont. mining machines	1.crushing 2.grinding 3.drying 4.roller milling 5.a portion goes to drying	cooling water, 11 m3/h dust control, 2 m3/h	yes	mine water collected in sump cooling water untreated	4699 m3/d, process 194 m3/d, mine 1611 m3/d, mine 1035 m3/d,mine	dry dust collectors	YES, Daphnia YES, Daphnia YES, Daphnia -	7.96 7.78 7.94 7.84	29.0 42.7 31.3 118.0	1.05 2.24 1.09 3.83	1.17 1.67 1.25 24.00	0.03 3.61 0.07 0.55
3.Westroc	Drumbo, Ont.	-	u/g	Anfo blasting	1.crushing 2.screening 3.stockpile and truck	none	no	mine water collected in sump	1197 m3/d, mine	-	NO	7.87	10.5	12.84	35.75	4.01
SUB-HEADING - GYPSUM IN CANADA OUTSIDE OF ONTARIO																
1.Domtar Inc.	Lussier River, B.C.	3	Open pit	blasting	1.crushing	none	no	no mine water or process water discharged	-	-	-	-	-	-	-	-
2.Westroc Industries	Invermere, B.C.	41	Open pit	Anfo blasting	1.crushing	only equipment wash in summer	no	no mine water	-	-	-	-	-	-	-	-
3.Domtar Inc.	Amaranth, Manitoba	-	Open pit	blasting	1.crushing	mine water to ditch	no	-	-							
4.Westroc Industries	Amaranth, Manitoba	15	Open pit	Anfo blasting	1.crushing 2.stockpile	none	no	settling of mine water in 2 ponds	10 800 m3/d		-	-	-	-	-	-
5.Fundy Gypsum Co. Ltd.	Windsor, Nova Scotia	60	Open pit	Anfo blasting	1.crushing 2.screening 3.transport by rail 4.anhydrite washing	washing	yes	settling of wash water in 2 ponds surface runoff collected in reservoirs	-	-	-	below regulations				
6.Georgia Pacific Corp.	Port Hawkesbury, Nova Scotia	30 5	Open pit	blasting	1.crushing	dust control	-	no effluent, due to evaporation	-							
7.Little Narrows Gypsum Co.	Little Narrows, Nova Scotia	40	Open pit	Ripping and Anfo blasting	1.crushing 2.screening	-	-	mine water to serires of 2 settling pond runoff is collected	20 200 m3/d	-	-	below regulations				
8.Nat'l Gypsum Ltd.	Milford, Nova Scotia	37	Open pit	Anfo blasting	1.crushing 2.screening	dust control equipment washing	-	mine water to settling sumps	-	waste fines sold to agriculture	NO	trout live in sumps				

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - GYPSUM IN USA																
1.	National City, Michigan	64	Open pit	Anfo blasting	1.crushing 2.roller milling 3.calcining	none	-	untreated mine water to river	-	-	-	-	-	-	-	-
2.	Blue Rapids, Kansas	31	u/g	blasting	1.crushing 2.calcining 3.regrinding 4.bagging/shipping	plaster operations	yes	settling pond	39-57 m3/d	dry dust collectors	-	-	-	-	-	-
3.	Shoals, Indiana	36	u/g	blasting	1.crushing 2.grinding 3.calcining 4.rehydrating	none	-	3 u/g settling sumps	450 m3/d	solids from sumps to old mine-workings		6.80	1-22	1.12 (average over 4 months)	-	-
4.	Sperry, Iowa	30	u/g	blasting	1.crushing 2.grinding 3.calcining	none	-	mine water to stream	-	-	-	-	-	-	-	-
5.	Grand Rapids, Michigan	144	u/g	blasting	1.crushing 2.grinding 3.calcining	dust control (minimal)	-	mine water to stream no treatment	-	-	-	-	-	-	-	-
SUB-HEADING - GYPSUM IN EUROPE																
1. British Gypsum	England	-	u/g	blasting	1.crushing	-	-	-	-	-	-	-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - TALC IN ONTARIO																
1. Canada Talc Ltd.	Madoc, Ont.	95	u/g	blasting	1.crushing 2.grinding 3.drying	none	-	mine water discharged to stream	4120 m3/d, mine	-	NO	8.12	9.4 Arsenic 20.5 ppb	1.00	2.29	0.03
2. Luzenac Inc.	Timmins, Ont.	15	Open pit	blasting	1.crushing 2.grinding 3.flotation 4.magnetic separation 5.filtration 6.drying 7.micronizing	flotation, 113 m3/h	no	process effluent to tailings pond / settling pond system, mine water to a settling pond, both systems discharge to wetlands	633 m3/d, process 516 m3/d, mine	-	NO	8.68 8.32	3.7 Arsenic 82.2 ppb 16.9 Arsenic 8.2 ppb	1.00 1.03	2.00 2.58	1.00 0.23
SUB-HEADING - TALC IN CANADA OUTSIDE OF ONTARIO																
1. Luzenac Inc.	St.Pierre de Broughton, Quebec	68	Open pit	Shovel sometimes blasted	1.crushing 2.grinding	none	-	no discharge	-	-	-	-	-	-	-	-
2. Bakertalc	South Bolton, Quebec	54	u/g	some blasting (dynamite) some slushing	1.crushing 2.grinding 3.flotation 4.drying 5.final milling	flotation, 14 m3/h	-	process effluents to tailings pond, overflow to secondary pond	-	-	-	-	-	-	-	-
SUB-HEADING - TALC IN USA																
1. Cyprus Industrial Minerals	Hammondsvill Vermont	24	Open pit	blasting	1.crushing 2.drying 3.grinding 4.flotation 5.filtering 6.flash drying	scrubber, 23 m3/h flotation, 79 m3/h	yes	series of 5 settling ponds	2195 m3/d	-	-	8.00 regulations 6.5 - 8.00	3.9 10.0	trace As, Fe, Ni, Be		
2. Pfizer Inc.	Dillon, Montana	36	Open pit	blasting	1.dry grinding and classification-also 1.crushing 2.flotation 3.thickening 4.drying 5.screening	-	yes	dewatering in tailings pond, no discharge, recirculated back to process	-	-	-	-	-	-	-	-
3. Montana Talc Co.	Three Forks, Montana	5	Open pit	ANFO blasting	1.crushing	minor amounts for dust control	N/A	no discharge	-	-	-	-	-	-	-	-
4. Gouverneur Talc Co.	Gouverneur, New York	35	u/g & Open	-	1.crushing	cooling water	N/A	settling pond	-	-	-	6-9	50 settleable solids: 0.1 ml/L	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - TALC IN EUROPE																
1.Finn-Minerals	Myllykoski, Finland	22	Open pit	Amfo blasting	1.crushing 2.grinding 3.flotation 4.drying 5.microgrinding	-	90%	series of 2 settling ponds	1233 m3/d	-	-	8.00 regulations: s.s. 4.0 t/a, Ni 0.65t/a, As 0.65 t/	-	-	-	-
2.Talcs de Luzenac	Pyrenees, S.W. France	111	Open pit	shovels	1.sorting 2.crushing 3.drying 4.grinding 5.micronising	dust control on roads, 120 m3/d	no	series of 2 basins	-	-	-	-	-	-	-	-
3. Handols Täljstens	Handol, Sweden	60	Open pit	blasting	1.sorting 2.crushing	none	no	minewater pumped to lake	30-40 m3/d, mine	-	-	-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - MAGNESIUM IN ONTARIO																
1. Timminco	Haley Sta., Ont.	-	Open pit	Tovex blasting	Pidgeon process 1.crushing 2.calcine 3.grinding 4.blending with fluorspar and ferrosilicon	cooling water, 27-137 m3/h	yes	cooling water overflows to either retention of if treated (no discharge), or into ditches for release into pond and discharged as required storm water is collected in ditches	2489 m3/d, process 122 m3/d, storm	baghouse, wet scrubber	NO NO	7.69 8.07	3.4 10.4	1.00 1.00	2.27 3.08	10.85 1.57
SUB-HEADING - GRAPHITE IN ONTARIO																
1.Cal Graphite Corp.	Kearny, Ont.	1	Open pit	Anfo blasting	1.crushing 2.conditioning 3.flotation 4.thickening 5.dewatering 6.drying 7.sizing	flotation, 6 000 m3/d dust control, cooling water	no	settling in tailings pond flows through filter dam to polishing pond	11 391 m3/d	recycle being planned	NO	6.35	12.8	1.63	21.48	-
SUB-HEADING - GRAPHITE IN CANADA OUTSIDE OF ONTARIO																
1. Stratmin	Mont-Laurier Que.	1	Open pit	blasting	1.crushing 2.grinding 3.flotation 4.thickening 5.drying 6.screening 7.bagging 8.sizing	flotation	yes	settling in tailings pond flows to clear water pond	-	-	-	7.00	-	-	-	-
SUB-HEADING - GRAPHITE IN EUROPE																
1. Skaland Graphitverk		61	u/g	-	1.crushing 2.grinding 3.flotation 4.drying	flotation, 90 m3/h	yes	water reclaimed from tailings thickener to process, thickened tailings discharged to fjord	-	-	-		5-6 % solids		-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - BASALT IN ONTARIO																
1. 3M Canada Inc.	Havelock, Ont.	-	Open pit	ANFO blasting	1.crushing 2.screening 3.sizing 4.colour coating	process water, 11 m3/h	yes	quarry water: sumps to settling ponds, to wetlands discharge	890 m3/d, quarry only	-	NO	8.13	9.0	1.12	0.47	0.80
SUB-HEADING - NEPHELINE SYENITE IN ONTARIO																
1.Unimin Canada Ltd.	Nephton, Ont.	-	Open pit	ANFO blasting	1.crushing 2.screening 3.mag.seperation	process water, 68 m3/h	none	addition of flocculant, settling in tailings pond, discharge to clarification pond	-	-	YES, Daphnia	8.61	47.1	1.04	4.88	0.20
2.Unimin Canada Inc.	Blue Mountain, Ont.		same mine as above		1.crushing 2.screening 3.mag.seperation	process water, 68 m3/h	none, but being installed	addition of flocculant, settling in tailings pond, discharge to environment	-	-	-	-	-	-	-	-
SUB-HEADING - NEPHELINE SYENITE IN EUROPE																
1. Sternoy	Alta, Norway	-	u/g	blasting	1.crushing 2.screening 3.mag.seperation	small amount for dust control	none	all dry tailings to fjord	-	-	-	-	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH, s.s. mg/L, O&G mg/L, phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - SALT IN ONTARIO													
1. The Canadian Salt Co. (Windsor Salt)	Ojibway, Ont.	35	u/g	blasting	1.crushing 2.screening 3.bagging/shipping	scrubber water, equipment washing	-	mine water collected in underground pond and pumped to surface sewer and river, no surface treatment	58m3/d, mine 400 m3/d, scrubber	-	YES, Daphnia, Trout	7.09 47.9 6.77 22.76 Chloride: 100,471 mg/L 7.25 228.2 4.00 5.83 Chloride: 31,900 ppm	6.41 1.49
2. The Canadian Salt Co. (Windsor Salt)	Windsor, Ont.	63	well	solution mining	1.evaporation 2.drying 3.screening 4.bagging/shipping	solution mining and evaporation, scrubbers, washing, 23 000 m3/d	yes	none	11000m3/d, process	covered stockpiles	YES, Daphnia, Trout	8.01 13.4 1.10 15.86 Chloride: 1,091 mg/L 12 to 15 t/d Cl during monthly evaporator wash	0.14
3.Sifto Canada Inc.	Goderich, Ont.	32	u/g	blasting	1.crushing 2.screening 3.bagging/shipping	equipment washing	-	mine water pumped to holding pond on surface (no discharge), storm water collected in 5 catchment basins, drain to environment	71 m3/d, mine	covered storage piles plan to install oil skimmer	YES, Daphnia, Trout	7.70 350.0 249.0 15.83 Chloride: 35,902 mg/L	2.40
4.Sifto Canada Inc.	Goderich, Ont.	56	well	solution mining	1.evaporation 2.drying 3.screening 4.bagging/shipping	solution mining and evaporation, scrubbers	yes	settling pond	8179 m3/d, process	product storage silos	YES, Daphnia	7.77 22.3 1.28 3.75 Chloride: 4,461 mg/L	0.22
SUB-HEADING - SALT IN CANADA OUTSIDE OF ONTARIO													
1.	Elk Point, Alberta	44	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers	yes	saline water down well for recycle	-	storage piles on concrete	-	regulations <1 kg/ton product or < 2kg/t daily max.	
2.	Unity, Sask.	42	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers washes	yes	saline water down well for recycle or down permanent disposal well	-	storage silos other storage covered by tarpaulins	-	1750 ppm Cl	
3.	Iles de la Madeleine, Quebec	-	u/g	blasting	1.crushing	-	-	settling pond	-	covered outdoor stockpiles	-	- - - -	-
4.	Pugwash, Nova Scotia	-	u/g	blasting	1.crushing 2.evaporation	evaporation, scrubbers, washes	-	settling tanks	-	-	-	salinity 25 to 300 ppm s.s. 50 ppm	
5.	Amherst, Nova Scotia	-	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers washes, 6.8 m3/a	no	none, discharge drains to tidal river	-	product storage in bins and silos	-	toxicity and bacteria testing	

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - SALT IN USA																
1.	Kanapolis, Kansas	78	u/g	blasting	1.crushing 2.grinding 3.separating	none	-	-	0	restrict outdoor storage < 12 hrs		no discharge				
2.	Hutchinson Kansas.	-	well	solution mining	1.evaporation	solution mining and evaporation	yes	discharge to brine field BMP	15,150 m3/d	dust collectors only condensate discharged	-	- Chloride: <10 mg/L	-	-	-	-
3.	Hutchinson Kansas	90	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers	yes	effluent to wells for recycle (large percent)	-	-	-	-	-	-	-	-
4.	Retsof, N.Y.	107	u/g	blasting	1.crushing 2.grinding	none	-	detention pond	1442 m3/d, mine 78 m3/d, storm water	crushing underground	- -	6.3-7.0 Chloride: 120,000 mg/L 7.4-7.7	- 1-230	- 1.40	- -	- -
5.	Lansing, N.Y.	75	u/g	blasting	1.crushing	-	yes	catch basin collect surface run-off no mine water to surface	227 m3/d (7 outfalls)	product stored covered wastes returned to mine crushing underground	-	7.2-9.0 Chloride: 40,000 mg/L	-	-	-	-
6.	Watkins Glen, N.Y.	98	well	solution mining	1.evaporation	scrubbers	yes	no treatment	757 m3/d, outfall A 32 555 m3/d, outfall B	product stored covered	-	6.4-9.0 Chloride: 416 mg/L 6.3-8.9 Chloride: 273 mg/L	1-62 0-5	- -	- -	- -
7.	Redmond, Utah	-	u/g	blasting	1.crushing	-	-	none. arid climate	-	-	-	-	-	-	-	-
8.	Breaux Bridge, Louisianna	50	well	solution mining	1.evaporation 2.drying 3.sizing	-	yes	all process water is recycled, only excess condensate water is treated in pond and discharged	1064 m3/d	holding tank used for recirculation	-	6.4-8 Chloride: <50 mg/L	8.0	-	-	0.05
9.	Rittman, Ohio	95	well	solution mining	1.evaporation	solution mining and evaporation	yes	saline waters recirculated from holding ponds & concrete cisterns, non-saline waters discharged	-	-	-	6.5-9.0	-	-	-	-
10.	Fairport, Ohio	32	u/g	blasting	1.crushing	small amount in scrubbers	-	-	-	-	-	-	-	-	-	-
11.	Manistee, Michigan	-	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers	-	detention pond	36 340 m3/d	cinder pond covered storage	-	7.1-9.2 Chloride: 188 mg/L	2	-	-	-
12.	St. Clair, Michigan	-	well	solution mining	1.evaporation	solution mining and evaporation, scrubbers	yes	settlers for sulphates, injected back to wells, with some discharge	-	all storage is enclosed	-	-	-	-	-	-
13.	Silver Springs, N.Y.	-	well	solution mining	1.evaporation	-	yes	lagoon	-	product storage silos	-	-	-	-	-	-
14.	Watkins Glen, N.Y.	-	well	solution mining	-	-	-	-	21 920 m3/d	-	-	7.0-8.8 Chloride: 102-1543 mg/L	-	-	-	-

TABLE 7-1 : INVENTORY OF SELECTED NON-METALLIC MINERAL PLANTS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O&G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - SALT IN EUROPE																
1. I.C.I.	Winsford, England	63	u/g & well	blasting, solution mining	1.crushing 2.grinding	condensate from evaporation is recycled	-	-	-	-		-	-	-	-	-
2. British Salt Ltd.	Middlewich, England	22	well	solution mining	1.evaporation	scrubbers	30%	none	-	-		-	-	-	-	-
3. New Cheshire Salt Works	Northwich, England	100	well	solution mining	1.evaporation	-	-	condensate discharged to drain field	-	covered storage		-	-	-	-	-
4. Irish Salt Mining	Carrickfergu N.Ireland	26	u/g	blasting	1.crushing 2.grinding	none	-	no effluent	-	underground salt storage		-	-	-	-	-
5. Sudwest-deutsche Saltwerk	Heilbronn, Germany	106	u/g	blasting	1.HMS 2.vacuum recrystallization	washes, scrubbers, heavy media separation, 50 000 m3/a	yes	all water returned to process	0 m3/d	-		no discharge				
6. Bayerische Berge Hutten und Salzwerk	Bad Reichenhall Germany	64	well	solution mining	1.evaporation 2.drying 3.screening 4.blending	scrubbers	no	none	-	-		regulations: 35 kg Cl per produced tonne				
7. Sudwest-deutsche Saltwerk	Bad Freidrichshall Germany	92	u/g	blasting	1.crushing 2.grinding 3.evaporation	none	-	none, no effluent	-	-		-	-	-	-	-
8. Cie de Salins	Loraine, France	150	u/g	blasting	1.crushing 2.grinding	none	-	-	-	-		-	-	-	-	-
9. As above		40	none	-	1.evaporation	-	-	none, no effluent	-	-		-	-	-	-	-
10. Dansk Salt	Mariager, Denmark	28	well	solution mining	1.evaporation	-	-	none, discharge to fjords	-	-		-	-	-	-	-

SECTION 8.

BEST AVAILABLE TECHNOLOGIES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

8. BEST AVAILABLE TECHNOLOGIES

Information on selected plant operations and practices in Ontario, the rest of Canada, U.S.A. and Europe is presented in Section 7. The full range of control and treatment technologies existing within each category is identified. This information serves as the basis for the identification of Best Available Technologies for the treatment of liquid effluents arising in the nine categories in the Non-Metallic Minerals Division.

Efforts are also made to determine the feasibility of transfer of technology from one category to another where similar effluent problems might occur. The choice of technologies is not limited to those presently employed in the Non-Metallic Minerals Division, but includes techniques employed in other industrial sectors. (e.g. Metal Mining Sector) and processes proven in pilot plant operation.

An Ontario BAT plant is chosen, where possible, for each category. This plant is deemed to be the one exhibiting the overall best quality of effluent. BAT plants are similarly chosen, where possible, for the United States and the rest of the world. All costs are expressed in second quarter, 1992 Canadian dollars, and exclude site specific costs related to such aspects as topography, site availablity and unique conditions.

Capital and operating costs are estimated for each plant to attain the effluent quality of the BAT plant in Ontario, United States and the rest of the world.

The costs are also estimated, where possible, for the following:

- Maximum pollution prevention
- Zero discharge

For the purpose of this document, Zero discharge is defined as zero volume discharge. Maximum pollution prevention is defined as the maximum decrease in contaminant release feasibly possible, based upon the consultant's best professional judgement. Generally, it is not possible to cost, or determine the efficiency of the practice, unless there is an exemplary existing operation after which other operations

could be modelled. If there are are no exemplary operations present, maximum pollution prevention generally involves either the implementation of best management practices or increased application of the best available treatment option.

The cost to produce a non toxic effluent can not be determined since the toxicity study is still in progress and the causes of toxicity are unkown at this time. Preliminary toxicity test results are used in determining relative levels of toxicity for the effluents examined.

8.1 CEMENT

The liquid effluents arising from cement production facilities in Ontario can comprise all or some of the following:

- Non contact cooling water
- Storm water runoff
- Quarry effluent

In cases where coal or coke instead of natural gas is used as fuel in the cement kiln, the liquid runoff from coal/coke piles is contained and managed to maximize evaporation thereby minimizing losses to seepage and surface runoff. Any net run-off from such storage piles and any other areas of the plant site is deemed to be plant effluent which may require treatment.

The major use of water in the cement plant is for indirect cooling of:

- Bearings on heavy equipment (e.g. crushers, mills and kilns)
- Hot cement after grinding
- Air compressors which supply air for blending and pneumatic conveying

Due to the lack of segregation between systems at most operations, the total plant effluent is usually a combination of the non contact cooling water and storm water runoff. This effluent can be contaminated with oil and grease and, during storms, with suspended solids from the runoff water.

The quarry effluent comprises precipitation and groundwater seepage and, in some instances, cooling water from the primary crusher and a fraction of the wash water used in the quarry. This effluent can be contaminated with suspended solids and oil and grease.

Based on the monitored effluent quality and Priority Parameters judged to be treatable, the application of Best Available Technology in the Cement category is, therefore, concerned with reduction in the level of suspended solids. Due to the lack of similarity between the plant effluent and quarry effluent streams,

the observed difference in existing treatment applied, and in most cases the separation between the two systems, the following selection of BAT plants and costing exercises consider separately Cement Plant Effluents and Cement Quarry Effluents.

8.1.1 CEMENT PLANT

Ontario BAT

The choice of the Ontario BAT plant in the cement category, based on best overall quality of effluent, could conceivably be between the Lafarge, Bath plant and St. Mary's Cement, St. Mary's.

The long term average (LTA) concentration of suspended solids in the process effluent at Lafarge was 11.5 mg/L. This was the lowest value recorded at the six cement plants despite the fact that this effluent stream is collected and discharged without any treatment other than assumed settling of solids in the collection system. The low value recorded for this operation is judged to be site specific and not subject to selection as the BAT level.

The plant effluents at the Essroc and St. Lawrence Cement plants, having LTA concentrations of suspended solids of 31.7 and 20.9 mg/L respectively, are not treated prior to discharge.

In the light of the above facts neither Lafarge, Bath nor St. Mary's Cement, St. Mary's were chosen to represent the Ontario BAT Plant, and as such no Ontario BAT plant is selected.

At the cement plant of Lafarge at Exshaw in Alberta non contact cooling water and plant site runoff are combined and fed to a 240m^3 engineered settling pond. This pond treats an average of 2,300m^3/day and has produced an effluent with a LTA concentration of suspended solids of 11mg/L during the past two years. The mean residence time of the effluent in the pond is calculated, from the above data, to be 2.5 hours.

The costs to achieve a LTA concentration of suspended solids of 11.5mg/L in the plant effluents at the six cement plants in Ontario are given in the column for World BAT in Table 8-1A. This could be considered as 'Canada BAT' although this category has not been considered in the Terms of Reference (Section 1.1) or in the foregoing data collection. The settling ponds are sized to provide a mean residence time of 2.5 hours at the design flow rate. The calculation of the design flow rate is explained in section 8.10.2.

US BAT

A US BAT plant could not be identified for the separate treatment of cement plant effluent despite exhaustive enquiries and due to sampling techniques different from those conducted under the MISA program.

Essroc's Nazareth Plant #1 in Pennsylvania is chosen as the US BAT plant for the treatment of the combined plant and quarry effluents. The process effluent, plant site run-off and quarry water are combined in a quarry sump and then pumped to two settling ponds in series. The individual ponds have estimated capacities of 13,600 m^3 and 29,7000 m^3. The calculated average residence times in the ponds are 15.oh and 32.7h based on the estimated LTA Flow Rate of 908 m^3/h. The concentration of suspended solids in grab samples of the effluent from the second settling pond were 1.8, 4.5 and 1.6 mg/L for the first three months of 1992.

World BAT

Insufficient data for plants outside North America are available to name a BAT plant. Discussions with various parties overseas indicate that the effluent quality achieved in other areas of the world is not better than that in North America. The Lafarge (Exshaw) plant is therefore selected as the World BAT plant.

Non-Toxic Effluent

The data available to date indicate that the effluents at the plants of Lafarge (Bath), Essroc Canada, St. Mary's Cement (Bowmanville) and St. Mary's (St. Mary's) have failed at times the toxicity tests for Rainbow Trout and/or Daphnia Magna.

Maximum Pollution Prevention

The costs for Maximum Pollution Prevention given in Table 8-1A comprise the cost of a cooling tower for the treatment and recycle of non contact cooling water and ponds for the removal of suspended solids. A 10% reduction in the LTA concentration of suspended solids in the treated effluent is judged to be attainable by inclusion of a cooling tower and a decant pond in addition to a setting pond.

The basis for estimating the capital and operating costs of the ponds and cooling towers is given in sections 8.10.2 and 8.12, respectively. Site specific costs are not included since detailed site investigations have not been conducted. Maximum pollution prevention measures are applied in this cost analysis regardless of the effluent currently obtained through the existing treatment facilties.

Zero Discharge

The costs for Zero Volume Discharge given in Table 8-1A are based on the combination of a cooling tower for the treatment and recycle of non contact cooling water and a single effect evaporator to treat 5% of the process effluent from each site. This latter stream corresponds to a bleed from the non contact cooling water circuit. A flash dryer is included in each evaporation circuit to produce a solid residue containing the suspended and dissolved solids in the feed to the evaporator.

The basis for sizing and estimating the costs of the cooling towers and evaporators is given in section 8.12.

8.1.2 CEMENT QUARRY

Ontario BAT

The lowest levels of suspended solids in Ontario Cement Quarry effluents were obtained at the Lafarge (Bath) and St. Mary's (St. Mary's) operations.

The LTA concentration of suspended solids in the quarry effluents were reported as being 45.5 mg/L at Lafarge and 45.1 mg/L at St. Mary's. At both these sites the quarry effluent is discharged after settling in ponds at the base of the quarry. These LTA concentrations of suspended solids are higher than many of those achieved by limestone quarries in the Aggregates Division, and thus are not judged to represent Ontario BAT.

US BAT

A US BAT plant could not be identified for the separate treatment of quarry effluent despite exhaustive enquiries.

Essroc's Nazareth Plant #1 in Pennsylvania is chosen as the US BAT plant for the treatment of the combined plant and quarry effluents. The process effluent, plant site run-off and quarry water are combined in a quarry sump and then pumped to two settling ponds in series. The individual ponds have estimated capacities of 13,600 m^3 and 29,7000 m^3. The calculated average residence times in the ponds are 15.oh and 32.7h based on the estimated LTA Flow Rate of 908 m^3/h. The concentration of suspended solids in grab samples of the effluent from the second settling pond were 1.8, 4.5 and 1.6 mg/L for the first three months of 1992.

World BAT

The level of data obtained for operations outside North America prevents the selection of a World BAT for cement quarries. From discussions with parties overseas it appears unlikely that the attained effluent quality is better than that reported for operations in North America.

Non-Toxic Effluent

The data available to date indicate that the effluents at the plants of Lafarge (Bath), Essroc Canada, St. Mary's Cement (Bowmanville) and St. Mary's (St. Mary's) have failed at times the toxicity tests for Rainbow Trout and/or Daphnia magna.

Maximum Pollution Prevention

The application of maximum pollution prevention replaces the application of identified BAT options since no BAT plants are selected.

The costs for Maximum Pollution Prevention given in Table 8-1B comprise the costs of ponds for the removal of suspended solids. A target value for the LTA concentration of suspended solids in the treated effluent is judged to be 15 mg/L, as attained by limestone quarries in the Aggregates Division.

The basis for sizing and estimating the costs of the ponds is given in sections 8.10.2 and 8.12, respectively.

Zero Discharge

The costs for Zero Discharge given in Table 8-1B are based on a single effect evaporator to treat the cement quarry effluent from each site. A flash dryer is included in each evaporation circuit to produce a solid residue containing the suspended and dissolved solids in the feed to the evaporator.

The basis for sizing and estimating the costs of the evaporators is given in section 8.12.

8.2 CHEMICAL LIME

The major uses of water in the production of chemical lime are for non contact cooling of equipment (e.g. kilns and crushers) and product and, in older plants, for the wet scrubbing of exhausts to recover dust extracted during processing. In newer plants dry dust collection using electrostatic precipitators and baghouses is practised.

The liquid effluents produced from Chemical Lime facilities include:

- Quarry Effluent
- Storm Water
- Process Water, from Scrubbers etc.
- Non-Contact Cooling Water

At installations using wet scrubbing, the scrubbers are operated in closed circuit with one or more settling ponds. The decant solution is partly recycled to the scrubbers while the balance is fed to a final settling pond. Quarry effluent and stormwater runoff from the plant area are in most cases pumped into the final settling pond. Non contact cooling water is drawn from the final settling pond.

Contaminants of concern in the quarry and stormwater effluents are restricted to suspended solids, and in extreme situations, pH control may be required.

Ontario BAT

The Chemical Lime plant of Stelco Incorporated at Ingersoll is chosen as the BAT plant in Ontario.

The liquid effluents at this site flow into an engineered settling pond which is 23m wide x 183m long x 3.7m deep. The LTA concentration of suspended solids in the pond effluent was reported as 7.0 mg/L. This was the lowest value recorded at the six lime plants. The mean residence time of the liquid in the settling pond is 14.9 hours at a flow rate equal to the LTA multiplied by the monthly four day variability factor, VF4.

The costs to reduce the LTA concentration of suspended solids in the effluents at the other five chemical lime plants to 7 mg/L are given in Table 8-2.

The settling ponds are sized to provide a mean residence time of 15 hours at the design flow rate. The calculation of the design flow rate is explained in section 8.10.2. The basis for estimating the capital and operating costs is described in section 8.10.2.

Allowances of $100,000 and $25,000 are provided for the installed cost of facilities for pH control at Beachvilime East and Reiss Lime, respectively. These include the cost of storage of reagent (sulphuric acid or carbon dioxide), reagent metering and an in-line pH control system. Reagent costs are estimated at $0.02/m^3 of effluent.

The unusually high phenolic content in the Reiss Lime effluent may be a result of the unique process, the use of wet scrubbers and the on-site storage of coke for fuel. While the applications of Ontario BAT options including settling ponds may reduce the level of this contaminant, the site specific characteristic may be further alleviated by various Pollution Prevention Practices discussed in Section 9.

US BAT

The US BAT plant is National Lime and Stone in Carey, Ohio where the suspended solids content of the effluent was reported as 5 mg/L. The long term quality of the effluent at this plant is not considered to be better than that at the Stelco Lime Works in Ingersoll, since the effluent data for National lime and Stone is based on grab samples only. The cost to achieve the level of Ontario BAT is therefore sufficient to equal or better US BAT for all the Ontario plants.

World BAT

Discussions with various parties overseas indicate that the effluent quality achieved in other areas of the world is not better than that in North America, although insufficient data are available to provide a direct comparison. The Stelco (Ingersoll) plant is selected as the World BAT.

Non-Toxic Effluent

Data available to date indicate that the effluents at the Beachvilime East Plant and Reiss Lime are toxic to Rainbow Trout and Daphnia magna.

Maximum Pollution Prevention

The costs for Maximum Pollution Prevention given in Table 8-2 comprise the cost to achieve the level of Ontario BAT plus a decant pond. Application of maximum pollution prevention is assessed regardless of the effluent quality obtained through the existing treatment system. The settling and decant ponds are arranged in parallel . Flow in excess of the design rate for the settling pond is diverted into the decant pond for the duration of the surge period. A 10% reduction in the LTA concentration of suspended solids in the treated effluent is judged to be possible by inclusion of a decant pond in addition to a settling pond.

The decant pond is sized to provide a mean residence time of 30 hours at the design flow rate, which allows suffcent time for settling followed by decant. The calculation of the design flow rate is explained in section 8.10.2. and the basis for estimating the capital and operating costs of the decant ponds is outlined in section 8.10.2. Site specific costs are not included.

Zero Discharge

The costs for Zero Discharge given in Table 8-2 are based on a single effect evaporator to treat the net liquid effluent from each site. A flash dryer is included in each evaporation circuit to produce a final solid residue containing the suspended and dissolved solids in the feed to the evaporator. The basis for sizing and estimating the costs of the evaporators is described in section 8.12.

8.3 Magnesium

Magnesium is produced via a dry, pyrometallurgical process by Timminco Metals at Haley Station in Ontario. The major raw materials are dolomite and ferrosilicon. The dolomite is obtained from quarries on the Haley site.

The liquid effluents arising from the operations at the Haley site, consist of:

- Quarry effluent
- Cooling water (direct and non contact)
- Storm water run-off from plant site
- Drainage from waste piles

Contamination by suspended solids is possible in all of these streams except the non contact cooling water. Oil and grease could be found in the quarry effluent, the non contact cooling water, the storm water runoff and the drainage from the waste piles.

The cost is zero to attain the level of Ontario BAT (only plant in Ontario), US BAT (no US sister plant known) and World BAT (believed to be World BAT). Maximum Pollution Prevention is achieved through Best Management Practices.

The estimated cost for Zero Discharge is based on a single effect evaporator followed by a flash dryer to treat the combined process effluent and stormwater, as outlined in section 8.12.

8.4 GRAPHITE

The recovery of graphite from crushed and milled ores is achieved by flotation at natural or slightly elevated pH. The flotation concentrate is dried and screened to produce the various graphite products.

The process effluent is the flotation tailings which are discharged in slurry form into a tailings pond. Other in-plant wastewater streams, including dryer scrubber water and washwater, are combined with the flotation tailings stream. The decant from the tailings pond flows to a polishing pond from where it

occurs in the tailings and polishing ponds. Residual organic reagents (typically kerosene and MIBC) used in the flotation process, excluding that portion which remains with the product or is lost through drying, are either evaporated, naturally degraded or adsorbed on settled solids during the period that the tailings water remains in the tailings and (polishing) settling ponds. Other effluents are the open-pit (mine) dewatering stream and stormwater from the plant area. Water used for non-contact cooling is recycled or discharged together with the tailings slurry.

The liquid effluents therefore include:

- Mine/Open Pit Effluent
- Stormwater
- Process Water Combined with Solid Tailings

The parameter to be controlled by BAT in the graphite category is suspended solids.

Control of suspended solids in mine and/or quarry water and stormwater is by sumps and settling ponds. The preferred technology for control of suspended solids in tailings is a tailings pond in series with a polishing pond, or two separate tailings ponds which are operated in batch mode with seasonal discharge. In the case of the single tailings pond and polishing pond, passive filtration has been incorporated into the downstream portion of the tailings dam to enhance removal of suspended solids prior to discharge to the polishing pond.

As a basic requirement the retention time of the process effluent in the two ponds should be maximized by:

- Maximizing the recycle of tailings pond decant solution for re-use in the process
- The use of berms and diversion ditches to minimize the runoff of contaminated water from surrounding areas particularly during the spring
- Diverting brooks and small rivers around the tailings catchment area
- Sizing the facility for suitable retention time

The cost is zero to attain the level of Ontario BAT (only plant in Ontario), US BAT (no US sister plant known) and World BAT (believed to be World BAT).

Maximum Pollution Prevention is achieved by recycle of water from the polishing pond to the process plant. The capital cost of this recycle system is based on the following:

- The use of two self-priming centrifugal pumps (one duty and one standby unit) on the banks of the clarification pond. The pumps are designed to deliver 375 m^3/h and will operate, on average, for 16 hours per day.

- One kilometre of 400 mm pipe laid on surface at a unit cost of $100.00/m.

- A 3,000 m^3 water tank at the plant site to provide surge capacity for eight hours at the design flow rate of 375 m^3/h.

- Factored allowances for civil works, electrical and instrumentation. It is assumed that electrical power is available at a point no further than 100 meters from where the water pumps will be located on the banks of the clarification pond.

- An allowance of 10% is provided to cover the cost of engineering.

- A 15% contingency is included.

The annual operating costs are estimated to be $71,000. This total comprises $40,000 for labour, $17,000 for electrical energy and $14,000 for maintenance supplies.

A 15% reduction in the LTA concentration of suspended solids in the treated effluent is judged to be possible by recycling water from the polishing pond to the process plant.

The cost for Zero Discharge given in Table 8-4 is based on pumped recycle and a single effect evaporator followed by a flash dryer. The design flow of 17,000 m^3/d for the evaporator is calculated as the long tern average flow rate, LTAF, multiplied by the monthly four day variability factor, VF4, less the water recycled from the polishing pond.

8.5 GYPSUM

In the underground mining of the raw material, any mine water is collected in sumps and pumped to surface storage ponds. Where heavy media separtion is employed in the gypsum recovery process, maximum utilization of mine water can be achieved by reclaim to the wet milling operations. Mine water can also be recycled to the wallboard manufacturing plant, from which there is no effluent discharge due to binding and evaporation. Any excess mine water is used either as once through, non contact cooling

water, or is discharged directly as a pond overflow. The process effluent arising from a gypsum operation which employs heavy media separation and flotation in the flowsheet is the flotation tailings.

Surface storage areas for waste rock and stockpiled ore generate stormwater run-off which is directed via settling sumps to site drainage.

Effluents from the gypsum operations therefore consist of:

- Minewater
- Process Effluent
- Stormwater
- Non-contact Cooling Water

The preferred technologies for control of suspended solids in minewater are underground sumps for primary settlement followed by surface settling ponds.

The preferred technology for control of suspended solids in process effluent, where flotation is used, is the tailings pond.

The costs to achieve the level of Ontario BAT, Maximum Pollution Prevention and Zero Discharge for mine water at CGC, Westroc and Domtar are given in Table 8-5. The costs to attain Maximum Pollution Prevention and Zero Discharge for process effluent at CGC and Domtar are also given in Table 8-5. The basis for estimating the size and costs of the settling and decant ponds and the evaporators is described in sections 8.10.2 and 8.12, respectively. The mean residence time in the settling and decant ponds are 24 and 48 hours, respectively, at the design flow rate. The settling and decant ponds are arranged in parallel. Flow in excess of the design rate for the settling pond is diverted into the decant pond. The residence time in the decant pond has to be sufficient to allow for settling and decant.

A 10% reduction in the LTA concentration of suspended solids in the treated effluent is judged to be possible by inclusion of a decant pond in the treatment of mine water for Maximum Pollution Prevention. The quality of effluent achievable in the treatment of process water at CGC and Domtar using settling and decant ponds is considered to be equal to that for mine water.

8.6 NEPHELINE SYENITE

The benefication of nepheline syenite at the Unimin plant in Nephton, Ontario is achieved by dry processing. The raw material is supplied to the plant from a quarry. Dust generated during processing is collected in baghouses.

Water is used for the following duties.

- Non contact cooling of major equipment such as crushers and air compressors.
- Slurrying of the reject solids (tailings) prior to being pumped to a tailings pond.
- Dust control

The effluents to be considered for treatment are:

- Quarry Water
- Process Effluent (Tailings Stream)
- Non Contact Cooling Water
- Stormwater from Plant Areas

The preferred technologies for control of suspended solids are quarry sumps and a tailings pond in series with a polishing pond. Passive filtration is used to filter tailings water.

The costs to achieve Maximum Pollution Prevention and Zero Discharge are given in Table 8-4. Maximum Pollution Prevention and Zero Discharge are achieved by full recycle of water from the clarification pond downstream of the tailings pond.

The capital cost of this recycle system is based on the following:

- The use of two self-priming centrifugal pumps (one duty and one standby unit) on the banks of the claification pond. The pumps are designed to deliver 100 m^3/h and will operate, on average, for 16 hours per day.

- One kilometer of 200 mm pipe laid on surface at a unit cost of $60.00/m.

- A 550 m^3 water tank at the plant site to provide surge capacity for eight hours at the design flow rate of 68 m^3/h.

- Two horizontal, centrifugal pumps (one duty and one standby unit) to supply water to the tailings pumping section of the plant.

- Factored allowances for civil works, electrical and instrumentation. It is assumed that electrical power is available at a point no further than 100 meters from where the water pumps will be located on the banks of the clarification pond.

- An allowance of 10% is provided to cover the cost of engineering.

- A 15% contingency is included.

The annual operating costs are estimated to be $48,000. This total comprises $39,000 for labour, $7,000 for maintenance supplies and $2,000 for electrical power.

8.7 BASALT

The production of basalt at Havelock in Ontario consists of quarrying by drilling, blasting, loading and hauling followed by crushing, screening, sizing and colour coating. The quarry effluent is pumped into a settling pond before discharge to a local watercourse. Process water used for colour coating is recycled in closed circuit with three settling ponds. There is no discharge of effluent from these ponds due to evaporative losses from the process.

Zero cost is associated with the attainment of Ontario BAT (only one plant), US BAT (no US sister plant known) and World BAT (no world sister plant known).

Maximum Pollution Prevention is achieved through the installation of a decant pond in parallel with the existing settling pond. A 10% reduction in the LTA concentration of suspended solids in the treated effluent is judged to be possible by inclusion of the decant pond.

The decant pond is sized to treat solution whenever quarry water is discharged at a rate which is in excess of the design flow rate into the settling pond. Flow in excess of the design flow rate is diverted into the decant pond where it is allowed to settle for a minimum period of 24 hours before decanting.

The decant pond is sized to store a flow rate equal to LTAF x VF1 for a period of 24 hours. The value of VF4 reported during the MISA program exceeded the value of VF1 (see Table 8-7) and hence the decant pond is sized using the VF1 factor only and not the difference between VF1 and VF4.

The cost for Zero Discharge is based on a single effect evaporator followed by a flash dryer. Cost data appear in Table 8-4. The basis for estimating the size and cost of the evaporators is outlined in section 8.12.

8.8 TALC

Talc is produced via either dry or wet processing. High quality ore is mined and dry processed by crushing, grinding, air classification and bagging for shipment as final product. In these operations the only liquid effluent is mine water which is partly used as non contact cooling water. At the one operation in Ontario this water is discharged directly to a local water course without treatment.

Lower grade ore is mined and processed by crushing, wet grinding and flotation and the recovered talc is dried, milled, air classified and bagged. In these operations the liquid effluents are as follows:

- Non-contact cooling water
- Flotation plant tailings
- Quarry effluent

The preferred technology for control of suspended solids are quarry sumps, and a tailings pond in series with a polishing pond(s) in cases where wet processing is employed.

The costs to attain Maximum Pollution Prevention and Zero Discharge are given in Table 8-4. The basis for estimating the size and costs of the ponds and evaporators is described in sections 8.10.2 and 8.12, respectively. The decant pond is sized to provide a mean residence time of 48 hours at the design flow rate. This allows sufficient time for settling and decant. A 10% reduction in the LTA concentrations of suspended solids in the treated mine water is judged to be possible by inclusion of the decant pond.

The mine and process effluents at Luzenac are combined to provide the feed to the evaporator and decant pond.

8.9 SALT

At the two major salt mines in Ontario (in Ojibway and Goderich) salt is extracted from underground by both rock salt mining and solution mining. At the operation in Ojibway the effluents arising from the rock salt operation are as follows:

- Wastewater from the wet scrubbers
- Run-off from salt storage areas
- Mine water

This combined saline effluent is discharged to surface receiving water.

The effluents from the multiple effect evaporation plant which recovers salt from the discharge from the brine wells are also discharged to the river. The major sources of this effluent are cooling water, evaporator bleeds, evaporator condensate and boiler room effluent.

Other waste streams are combined and returned to the brine recirculation circuit for return to the brine wells. In the event of an imbalance in this circuit, excess water is also discharged to the river.

The underground rock salt mine at Goderich accounts for the major portion of the salt produced at this site. The water from the underground operation is pumped to a surface exfiltration pond which has no overflow. Several waste streams from the evaporation plant are combined and discharged via a settling pond.

The concentrated saline effluents to be treated in this category contain not only sodium and chloride ions but also significant concentrations of calcium, magnesium, sulphate and other ions. The high concentration of salt in these effluents precludes the use of ion exchange as a method of control.

Membrane processes such as reverse osmosis and electrodialysis have been widely used in the production of potable water from seawater and brackish water. However, the application of these processes to wastewater treatment is still at the developmental stage.

Thermal processes such as evaporation and freeze desalination hold out the most promise for the treatment of wastewaters in this category. However, freeze desalination has not yet been applied on a full-scale, commercial plant.

Efforts to implement best management and best processing practices to reduce contaminants to the lowest feasible levels are recommended.

The costs to attain the level of Ontario BAT and Maximum Pollution Prevention for control of suspended solids appear in Table 8-6. The basis for estimating the size and costs of the settling and decant ponds is outlined in section 8.10.2. Allowance is also made for lining of the pond at a unit cost of $12.00/m^2$. The settling ponds are sized to provide a mean residence time of 24 hours at the design flow rate. The size of the decant ponds is such that the mean residence time of 48 hours is considered to be long

enough to allow sufficient time for settling and decant. The settling and decant ponds are arranged in parallel. Flow in excess of the design rate for the settling pond is diverted into the decant pond.

The target value for the LTA concentration of suspended solids in the treated effluent from the brine operation at Canadian Salt (Windsor) is 10mg/L. The inclusion of a decant pond is expected to reduce this LTA concentration by 10%, i.e to 9 mg/L.

The same quality of effluent is considered to be achievable in the application of settling and decant ponds in the treatment of the effluents at the rock salt operations of Canadian Salt (Ojibway) and Sifto Salt (Goderich) and the brine operation of Sifto Salt (Goderich).

In the case of the liquid effluent from the brine operation at Canadian Salt in Windsor, the capital and operating costs were provided in a personal communication from the Canadian Salt Company Limited. These costs take into account the site specific factors which include the following:

- The lined ponds are constructed above grade since the water table is close to natural ground level
- Borrow material is used for construction of the dykes
- The effluent from the ponds is pumped over a considerable distance before disposal in a river

The costs to achieve Zero Discharge given in Table 8-6 are based on the use of a multiple effect, vapour compression evaporator followed by a flash dryer. The basis for estimating the size and costs of the evaporators is described in section 8.12.

8.10 CONTROL OF SUSPENDED SOLIDS

8.10.1 Quarry Sumps

The three main purposes of this sump are as follows:

- to serve as the catchbasin for rainfall runoff
- to act as a primary settling basin
- to provide a reservoir for a dewatering pump

The size and location of the sump are dependent on a number of factors which include the following:

- the available quarry area
- the peak rainfall runoff to which the pit might be subjected
- groundwater inflow

- the availability of additional storage (e.g. a low bench) that can be allowed to fill during periods of peak runoff and groundwater inflow
- anticipated pumping capacity
- access to the sump for cleaning

At sites which have more than one quarry, the sumps can be used in series with liquid effluent being pumped only from the last sump.

The location of the sump pump is one of the most critical aspects affecting the quality of the discharged effluent. The pump suction line should be located in a quiescent area of the sump in order to take full advantage of settling in the sump and to avoid the introduction of material that would produce levels of suspended solids above the regulatory limits.

8.10.2 Settling Ponds

Design

The mechanism of separation in settling ponds, in the absence of any chemical pretreatment (e.g. flocculation) of the feed, is "free" or "ideal" settling in which solid particles settle independently of one another. This settling regime is governed by Stoke's Law which expresses the settling velocity of particles, assumed to be spherical, in terms of their physical properties (diameter and specific gravity) and the kinematic viscosity of water.

The design of a settling pond is dependent upon a number of factors which include the following:

- expected range of concentration of suspended solids in the influent
- size distribution of suspended solids in the influent
- expected range of water temperature
- expected range of flow rate of the influent
- maximum allowable concentration of suspended solids in the effluent.

The first step in the design procedure is to determine the diameter of the smallest particle to be settled out in order to meet the effluent limit. The size of this particle is calculated from the flow rate of influent and the size distribution of suspended solids in the influent.

The next step is to calculate the settling velocity of this particle using Stoke's Law.

$$Vs = gD^2 (Ss-1)/18u$$

where	Vs	=	settling velocity (cm/sec)
	g	=	gravitational acceleration (981 cm/sec^2)
	u	=	kinematic viscosity of water (cm^2/sec)
	Ss	=	specific gravity of particle
	D	=	diameter of particle (cm)

The area in plan, A, of the settling pond is then calculated from the following equation for the removal ratio R.

$$R = Vs/Vo = (C_1-C_2)/C_1$$

where	Vs	=	settling velocity of smallest particle (m/h)
	Vo	=	overflow velocity (m/h) = Q/A
	Q	=	flow rate of influent (m^3/h)
	C_1	=	concentration of suspended solids in the influent (mg/L)
	C_2	=	concentration of suspended solids in the effluent (mg/L)

This equation is based on the assumption that all particles with a settling velocity greater than the overflow velocity will settle out.

Dimensions of the pond are chosen to ensure that scouring does not occur and that turbulence and short circuiting are minimized.

Scouring occurs when the horizontal velocity of the fluid is high enough to pick up settled particles from the bottom of the pond and sweep them away. The cross-sectional area of the pond should be large enough to ensure that the horizontal velocity does not exceed the scour velocity.

Turbulence caused by "in-pond" factors can be controlled by inlet and outlet conditions and by sizing the pond correctly.

Various inlet configurations are used within this and related industries to minimize turbulence through the partition of flows. A well designed system encountered by the study team was the UL200 system currently in use at the Petschmorgen Works of Fuchs' Sche Tongruben in Germany. With this system the settling pond is preceded by a small "stilling" basin into which the feed pipe discharges. The

overflow from this basin flows via three pipes into a 400 mm diameter distributor pipe which extends across the width of the settling pond. The incoming fluid is discharged from this distributor through holes in a direction opposite to its ultimate direction of flow toward the outlet of the pond. A section through this feed distributor is shown in Figure 8-1. Special design considerations and/or modifications may be required to address winter freezing conditions, especially where intermittent flows are expected.

The preferred outlet assembly consists of a pipe which extends across the width of the pond. The effluent water flows via a V-notch weir into cutaways at the top of the pipe. The V-notch weir extends along the full length of the outlet pipe.

Turbulence can also be created by external factors such as wind. Wind breaks may be necessary to reduce the effects of such turbulence in extreme cases.

Long, narrow, rectangular ponds are generally affected less by turbulence and short circuiting. As a general rule the ratio of the length to the width should not be less than 5:1.

<u>Capital Costs</u>

The installed cost of a settling pond can vary greatly depending upon a number of factors such as:

- extent of excavation required
- need for blasting
- surrounding topography
- extent of diversion of storm water runoff around the pond
- access to the pond for cleaning

For the purposes of this study, the design of the settling ponds is based on the following assumptions:

. a relatively flat site is available at no cost
. soil can be excavated without the need for any blasting
. excavated soil is suitable for the building of dykes around the four sides of the pond
. no borrow material is needed for the construction of the dykes
. sides of the excavation and the dykes have a slope of 2:1
. crest width of the dykes is 5 metres
. ratio of the length to the width at the top of the settling pond is 5:1
. influent is evenly distributed across the full width of the pond
. combined feed is available either at the discharge side of a feed pump or at an elevation sufficient for gravity flow into the pond

- pond effluent is collecting evenly across the full width of the pond
- discharge flows by gravity to its point of release to the environment

The capital cost of each engineered settling pond is based on the following:

- cost of earthworks is $10.00/$m^3$ of excavated soil. This figure includes the cost of site preparation, excavation, compaction of dykes and surface grading.
- settling pond is unlined
- cost of the feed distribution and overflow collection systems is $1,500 /m of pond width
- an allowance is made for a feed pipe laid on surface over a distance of 500 metres. The unit installed cost of this piping varies from $50.00/m for 150mm pipe to $110.00/m for 450mm pipe.
- an allowance is made for a discharge pipe laid on surface over a distance of 500 metres. The unit installed cost of this piping varies from $80.00/m for 225mm pipe to $200.00/m for 800mm pipe
- an allowance of 10% is provided to cover the costs of engineering
- a 15% contingency is included
- cost of disposal of dredgings is excluded

The design and capital cost of each decant or batch settling pond includes all of the items listed above with the following exceptions:

- decant pond is square in cross-section
- an allowance of $1,500/m of pond width for the feed distribution and overflow collection systems is excluded

The design flow rate, into the settling pond, FSP, is determined from the following formula, except where otherwise noted, and incorporates MISA monitoring values and definitions.

$$FSP = LTAF \times VF4$$

where, LTAF = long term average flow rate (m^3/d)

VF4 = monthly four day variability factor (calculated form 95th percentile of data [P95]/long term average)

The design flow rate into the decant pond, FDP, is determined from the following formula, except where otherwise noted.

$$FDP = LTAF \times (VF1 - VF4)$$

where, VF1 = daily variability factor

(calculated from 99th percentile of data [P99]/long term average)

The settling and decant ponds are arranged in parallel. The decant pond is operated on a batch basis.

Values of LTAF, VF1 and VF4 are listed in Table 8-7.

OPERATING COSTS

Labour and machinery are required for maintenance of a settling pond to avoid adverse effects on its operation. Typical items on the maintenance list are as follows:

- cleaning of the pond on a regular schedule (annual or less frequent basis) to ensure peak efficiency at all times
- disposal of settled solids in a disposal area such that they do not wash back into the pond or cause off-site sedimentation problems
- maintenance of slopes or banks
- periodic checking and repair of pipes, weirs and structures
- maintenance of storm water diversion ditches

The annual cost of labour and machinery is estimated to be $20,000 for a 2,000 m³ pond. This figure is estimated to increase to $30,000 for a pond with a capacity of 20,000 m³. No allowance is made in the operating costs for the addition of treatment aids such as flocculants and coagulants.

8.11 CONTROL OF OTHER PARAMETERS

8.11.1 Oil and Grease

In cases where oil and grease is present in significant quantities which readily coalesce to form a separate phase, the best available technology for removal is the use of interceptors which rely on the principle of gravity separation. The separation, containment and removal devices may be classified as "in-line" or "on-surface".

"In-Line" Separators

A diagram of a typical in-line device is shown in Figure 8-2. These interceptors are appropriately baffled to ensure that only water exits while oil and grease are retained within the unit. The accumulated oil and grease is usually drawn off manually using a vacuum technique. Provision can be made for automatic (continuous or intermittent) draw-off of oil with the elevation of the draw-off nipple being set such that no

water is taken off and only the minimum quantity of oil is resident in the interceptor at any time. These separators are suitable for installation both above and below grade. Their application is limited to flow rates of up to 50 m^3/h in a single stream.

The separators are sized to allow for a minimum retention time of 5 minutes. In addition, the interceptor area should not be less than 0.064m^2 per m^3/h (i.e. 3.1 ft^2 per 1,000 gph).

Separators of this type are treating the non contact cooling water at St. Mary's Cement, St. Mary's.

The installed cost of an above grade unit with manual draw-off and designed to treat 50m^3/h would be approximately $8,000. The unit has no moving parts or other wear parts which require replacement. The only operating cost would be the cost of the labour required for regular inspection and the draw-off of accumulated oil and grease.

"On-Surface" Separators

"On-Surface" separators can be applied in quarry sumps and in settling ponds.

One type of separator takes the form of a baffle which would be mounted in a fixed position between the main body of liquid in a settling pond and the overflow weir for the treated effluent. Maintenance in winter may be required to ensure proper operation during periods of heavy ice formation. Options would include the physical removal of ice, or air injection systems to maintain ice free conditions in the immediate area of the baffle.

Oil and grease floating on the surface of the liquid can be removed using an oil skimmer. A typical skimmer system is based on the fact that a metal or plastic belt attracts waste oil and carries it past doctor blades that remove it to drain into external storage equipment.

Booms may also be applied for the containment of oil and grease floating on the surface of a liquid.

8.11.2 Ammonia / Ammonium

Ammonia and the ammonium ion are generally found in the effluents from underground mines and quarries where ANFO (ammonium nitrate/fuel oil) and other ammonia/nitrate based explosives are used.

Strict handling procedures for ANFO and the immediate clean up of spills are pre-requisites for the control of ammonia in liquid effluents. Also, unlike metal mining, major industrial mineral producers tend

to utilize quarry operations, rather than underground operations. As such, explosive use per ton of product tends to be comparatively low.

In agricultural areas there is also a potential for introduction of ammonia/ammonium into ground waters from other sources. (e.g. fertilizers)

8.11.3 Phenolics

Contamination of liquid effluents by phenolic compounds in the Non-Metallic Minerals Division can be caused by the use of process reagents which contain phenol and its derivatives. Phenolics also derive naturally from the breakdown of vegetation.

Phenol based flotation reagents (e.g. cresylic acid) were in use until recent times. A large number of nonphenolic flotation frothers (e.g. methyl isobutyl carbinol) have been developed and applied without adverse effects on the recovery efficiency of the flotation circuit.

The consequences of substitution of nonphenolic reagents for phenol containing collectors has proven feasible in many instances without adverse metallurgical or economic consequences. The consequences of substitution are, however, site dependent and the introduction of different reagents requires extensive experimentation.

8.11.4 Dissolved Solids

Water which comes into contact with raw materials and products can become contaminated with dissolved ions. In the Non-Metallic Minerals Division the two major contaminants to be considered are sulphate and chloride.

Efforts to implement best management and best processing practices to reduce contaminants to acceptable levels are recommended.

8.12. COST BASIS FOR EVAPORATORS AND COOLING TOWERS

8.12.1 SINGLE EFFECT EVAPORATORS

The design criteria and capital and operating costs to evaporate 1,000 and 10,000m^3/day of liquid effluent to dryness are presented below. The costs are based on the use of a natural gas fired evaporator following by flash drying to produce a dry solid residue for disposal.

Design Criteria	Units	Case A	Case B
No. of operating days per year	#	365	365
Total water vaporized	m^3/d	1,000	10,000
Water vaporized in evaporator	m^3/d	950	9,500
Waste vaporized in flash dryer	m^3/d	50	500
Efficiency of vaporization process	%	75	75

CAPITAL AND OPERATING COSTS

Installed Cost	$	2,200,000	8,800,00
Annual Operating Cost	$	4,500,000	40,500,00

The capital costs vary with design capacity to the power of 0.6 and are based on the use of carbon steel as the material of construction for the evaporator and flash dryer. No allowance is made for the cost of disposal of the solid residue and feed pretreatment (e.g. pH adjustment and deaeration), if required.

Fuelling by natural gas accounts for over 90% of the total operating cost. The unit cost of natural gas is \$129/million m^3.

The design flow rate of the feed to the evaporators is calculated as the LTA flow rate multiplied by the monthly four day variability factor, VF4 as defined in Section 7.4..

8.12.2 MULTIPLE EFFECT EVAPORATORS

Natural gas fired evaporators are proposed for the treatment of saline effluents in the salt category.

The capital cost of an evaporator followed by flash drying to produce a dry solid residue from the evaporation of 1,000m^3/day of liquid effluent is estimated to be \$6,600,000. This cost is based on the use of a high nickel alloy as the material of construction for the evaporator and flash dryer. No allowance is made for the cost of disposal of the salt residue.

The cost of evaporators with varying design capacities is calculated using a 0.6 power factor.

The operating cost of multiple effect evaporators is calculated as one third of the cost of operating a single effect system with the same design capacity.

The design flow rate of the feed to the evaporators is calculated as the LTA flow rate multiplied by the monthly four day variability factor, VF4.

8.12.3 COOLING TOWERS

The capital cost of an induced draft cooling tower for the treatment of the non contact cooling water in a 500,000 t/a cement plant is estimated to be $470,000. The cost of cooling towers with varying design capacities is calculated using a power factor of 0.6.

The annual operating costs are estimated to be $180,000 and include the cost of maintenance, sludge removal, chemicals, labour and electrical power. Operating costs are considered to vary with cement capacity to the power of 0.9.

TABLE 8-1A – NON-METALLIC MINERALS DIVISION

CATEGORY: **CEMENT [PLANT EFFLUENT]**

COSTS OF BAT OPTIONS

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT (1)	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Lafarge, Bath	Not considered to be BAT {11.5}	Lack of data to identify US BAT	Settling pond $148,000 $20,000 [11.5 to 11.0]	Cooling tower settling pond + decant pond $940,000 $358,000 [11.0 to 10.0]	Cooling tower, + evaporator $1,530, 000 $1,310,000
Lafarge, Woodstock	Not considered to be BAT {231.9}	Lack of data to identify US BAT	Settling pond $90,000 $14,000 [231.9 to 11.0]	Cooling tower, settling pond + decant pond $710,000 $220,000 [11.0 to 10.0]	Cooling tower + evaporator $1,070,000 $760,000
St. Lawrence Cement	Not considered to be BAT {20.9}	Lack of data to identify US BAT	Settling pond $214,000 $22,000 [20.9 to 11.0]	Cooling tower, settling pond + decant pond $1,392,000 $646,000 [11.0 to 10.0]	Cooling tower + evaporator $3,180,000 $4,900,000
Essroc Canada	Not considered to be BAT {31.7}	Lack of data to identify US BAT	Settling pond $148,000 $18,000 [31.7 to 11.0]	Cooling tower, settling pond + decant pond $934,000 $374,000 [11.0 to 10.0]	Cooling tower $1,960,000 $2,180,000
St. Mary's Cement, St. Mary's	Not considered to be BAT {18.4}	Lack of data to identify US BAT	Settling pond $165,000 $19,000 [18.4 to 11.0]	Cooling tower, settling pond + decant pond $1,058,000 $276,000 [11.0 to 10.0}	Cooling tower + evaporator $2,050,000 $2,630,000
St. Mary's Cement, Bowmanville	Not considered to be BAT {115.2}	Lack of data to identify US BAT	Settling pond $137,000 $18,000 [115.2 to 11.0]	Cooling tower, settling pond + decant pond $902,000 $275,000 [11.0 to 10.0]	Cooling tower + evaporator $1,670,000 $1,780,000

(1) Plant of Lafarge at Exshaw, Alberta was chosen as World BAT. Capital costs appear above annual operating costs.
Figures in { } LTA are concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] LTA are concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application. Site specific costs are not included.

TABLE 8-1B - NON-METALLIC MINERALS DIVISION
COSTS OF BAT OPTIONS

CATEGORY: CEMENT [QUARRY EFFLUENT]

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Lafarge, Bath	Not considered to be BAT {45.5}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond (1) + decant pond $184,000 $39,000 [45.5 to 15.0]	Evaporator $2,860,000 $6,800,000
Lafarge, Woodstock	Not considered to be BAT {102.9}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond $487,000 $56,000 [102.9 to 15.0]	Evaporator $6,600,000 $25,700,000
Essroc Canada	Not considered to be BAT {31.5}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond $207,000 $39,000 [31.5 to 15.0]	Evaporator $5,200,000 $17,400,000
St. Mary's Cement, St. Mary's	Not considered to be BAT {45.1}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond $448,000 $55,000 [53.1 to 15.0]	Evaporator $9,400,000 $44,700,000
St. Mary's Cement, Bowmanville	Not considered to be BAT {200.6}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond $231,000 $43,000 [200.6 to 15.0]	Evaporator $3,400,000 $9,100,000

(1) To attain level demonstrated by limestone quarries in Aggregates Division.
Capital costs appear above annual operating costs.
Figures in { } are LTA concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] are LTA concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application.
Site specific costs are not included.

TABLE 8-2 – NON-METALLIC MINERALS DIVISION
COSTS OF BAT OPTIONS

CATEGORY: CHEMICAL LIME

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Stelco Lime	Zero cost {7.0}	Zero cost	Zero cost	Decant pond $174,000 $27,000	Evaporator $15,300,000 $97,100,000
Steetley Lime	Settling pond $234,000 $26,000 [11.2 to 7.0]	Settling pond $234,000 $26,000 [11.2 to 7.0]	Settling pond $234,000 $26,000 [11.2 to 7.0]	Settling pond + decant pond $447,000 $55,000 [7.0 to 6.3]	Evaporator $10,600,000 $54,300,000
Beachvilime East	Settling pond + pH control $444,000 $238,000 [23.8 to 7.0]	Settling pond + pH control $444,000 $238,000 [23.8 to 7.0]	Settling pond +pH control $444,000 $238,000 [23.8 to 7.0]	Settling pond, decant pond + pH control $732,000 $270,000 [7.0 to 6.3]	Evaporator $16,900,000 $114,000,000
Beachvilime West	Settling pond $261,000 $27,000 [54.5 to 7.0]	Settling pond $261,000 $27,000 [54.5 to 7.0]	Settling pond $261,000 $27,000 [54.5 to 7.0]	Settling pond + decant pond $416,000 $53,000 [7.0 to 6.3]	Evaporator $12,200,000 $67,300,000
Guelph Dolime	Settling pond $207,000 $25,000 [20.5 to 7.0]	Settling pond $207,000 $25,000 [20.5 to 7.0]	Settling pond $207,000 $25,000 [20.5 to 7.0]	Settling pond + decant pond $356,000 $51,000 [7.0 to 6.3]	Evaporator $9,000,000 $42,100,000
Reiss Lime	Settling pond +pH control $100,000 $23,000 [16.8 to 7.0]	Settling pond +pH control $100,000 $23,000 [16.8 to 7.0]	Settling pond +pH control $100,000 $23,000 [16.8 to 7.0]	Settling pond, decant pond +pH control $142,000 $39,000 [7.0 to 6.3]	Evaporator $2,100,000 $4,100,000

Capital costs appear above annual operating costs.
Figures in { } are LTA concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] are LTA concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application.
Site specific costs are not included.

TABLE 8-3

TABLE 8-3 – NON-METALLIC MINERALS DIVISION
COSTS OF BAT OPTIONS

CATEGORY: MAGNESIUM

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Timminco Limited	Not applicable Only one plant {3.4}	Not applicable No US sister plant known	Zero cost Believed to be World BAT	Best Management Practice	Evaporator $4,700,000 $15,000,000

Capital costs appear above annual operating costs.
Figure in { } is LTA concentration in mg/L for suspended solids reported during the MISA program.
Site specific costs are not included.

TABLE 8-4 - NON-METALLIC MINERALS DIVISION

CATEGORY: **BASALT, GRAPHITE, NEPHELINE SYENITE AND TALC**

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
3M Canada, Havelock	Not applicable Only one plant {9.0}	Not applicable No U.S. plant known.	Not applicable No world plant known.	Decant pond $85,000 $22,000 [9.0 to 8.1]	Evaporator $2,500,000 $5,600,000
Cal Graphite, Kearney	Not applicable Only one plant {12.8}	Not applicable No U.S. plant known.	Zero cost Believed to be World BAT	Pumped recycle $906,000 $71,000 [12.8 to 10.9]	Pumped recycle + evaporator $13,000,000 $67,200,000
Unimin Nephton	Not applicable Only one plant {47.1}	Not applicable No U.S. plant known.	Zero cost Believed to be World BAT	Pumped recycle $410,000 $40,000	Pumped recycle $410,000 $40,000
Luzenac, Timmins	Not applicable Only one plant Mine {16.9} Process {3.7}	Zero cost US sister plant has comparable effluent	Lack of data to identify World BAT	Decant pond for mine water $52,000 $18,000 [16.9 to 15.2]	Evaporator $3,100,000 $7,800,00
Canada Talc, Madoc	Not applicable Only one plant Mine {9.4}	Not applicable No U.S. plant known	Not applicable No World plant known	Decant pond $253,000 $32,000 [9.4 to 8.5]	Evaporator $7,900,000 $33,900,00

Capital costs appear above annual operating costs.
Figures in { } are LTA concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] are LTA concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application.
Site specific costs are not included.

TABLE 8-5 - NON-METALLIC MINERALS DIVISION

CATEGORY: GYPSUM

COSTS OF BAT OPTIONS

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
CGC, Hagersville (Mine Water)	Settling pond $205,000 $25,000 [17.6 to 10.5]	Zero cost Lesser technology at U.S. sister plant	Lack of data to identify World BAT	Settling pond + decant pond $392,000 $54,000 [10.5 to 9.5]	Evaporator $11,600,000 $62,600,000
Westroc, Drumbo (Mine Water)	Zero cost {10.5}	Not applicable No U.S. plant known.	Lack of data to identify World BAT	Decant pond $85,000 $22,000 [10.5 to 9.5]	Evaporator $3,200,000 $8,100,000
Domtar Gypsum, Caledonia (Mine Water)	Settling pond $167,000 $23,000 [63.7 to 10.5]	Not applicable No U.S. plant known.	Lack of data to identify World BAT	Settling pond + decant pond $334,000 $51,000 [10.5 to 9.5]	Evaporator $10,500,000 $53,800,000
CGC Hagersville (Process Water)	Not considered to be BAT {39.5}	Zero cost Lesser technology at U.S. sister plant	Lack of data to identify World BAT	Settling pond + decant pond $385,000 $54,000 [39.5 to 9.5]	Evaporator $3,500,000 $9,200,000
Domtar Gypsum Caledonia (Process Water)	Not considered to be BAT {29.0}	Not applicable No U.S. plant known	Lack of data to identify World BAT	Settling pond + decant pond $448,000 $57,000 [29.0 to 9.5]	Evaporator $8,000,000 $34,700,000

Capital costs appear above annual operating costs.
Figures in { } are LTA concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] are LTA concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application.
Site specific costs are not included.

TABLE 8-6 – NON-METALLIC MINERALS DIVISION

CATEGORY: SALT

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Canadian Salt, Windsor. [Rock salt mine]	Not considered to be BAT {205.4}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond (1) $113,000 $30,000 [205.4 to 9.0]	Evaporator $4,100,000 $700,000
Sifto Salt, Goderich. [Rock salt mine]	Not considered to be BAT {350.0}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond (1) $60,000 $24,000 [350.0 to 9.0]	Evaporator $1,500,000 $146,000
Canadian Salt, Windsor. [Brine operation]	Zero cost {13.4}	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond decant pond (1) $1,400,000 $270,000 [13.4 to 9.0]	Evaporator $62,300,00 $53,000,000
Sifto Salt, Goderich. [Brine operation]	Settling pond (1) $319,000 $27,000 [22.3 to 13.4]	Lack of data to identify US BAT	Lack of data to identify World BAT	Settling pond + decant pond (1) $485,000 $53,000 [13.4 to 9.0]	Evaporator $28,000,000 $14,900,000

(1) For control of suspended solids only.
Capital costs appear above annual operating costs.
Figures in { } are LTA concentrations in mg/L reported during the MISA program for suspended solids.
Figures in [ ] are LTA concentrations in mg/L of suspended solids in the monitored effluent and the level to be attained by BAT application.
Limited site specific costs are included.

INDUSTRIAL MINERALS SECTOR - NON-METALLIC MINERALS DIVISION

TABLE 8-7: EFFLUENT FLOW RATE DATA

CATEGORY: CEMENT

NAME OF PLANT	EFFLUENT	LTAF	VF1	VF4
Lafarge, Bath	Plant	2959	2.334	1.372
	Quarry	554	8.486	2.765
Lafarge, Woodstock	Plant	598	12.293	3.810
	Quarry	1610	13.725	3.842
St. Lawrence Cement	Plant	17030	1.333	1.108
Essroc Canada	Plant	7104	1.275	1.090
	Quarry	2988	1.640	1.373
St. Mary's Cement,	Plant	4834	5.596	2.098
St. Mary's	Quarry	8483	2.068	1.308
St. Mary's Cement,	Plant	3456	4.527	1.863
Bowmanville	Quarry	983	5.624	2.104

LTAF = Long term average flow rate (m^3/d)

VF1 = Daily variability factor

VF4 = Monthly four day variability factor

INDUSTRIAL MINERALS SECTOR - NON-METALLIC MINERALS DIVISION

TABLE 8-7: EFFLUENT FLOW RATE DATA (CONTINUED)

CATEGORY: CHEMICAL LIME

NAME OF PLANT	EFFLUENT	LTAF	VF1	VF4
Stelco Lime Works	Process	21000	1.638	1.195
Steetley Lime	Process	8825	3.079	1.544
Beachvilime East	Process	21087	2.492	1.410
Beachvilime West	Process	13873	1.770	1.231
Guelph Dolime (1)	Process	7735	2.245	1.345
Reiss Lime (2)	Process	575	2.313	1.565

CATEGORY: MAGNESIUM

NAME OF PLANT	EFFLUENT	LTAF	VF1	VF4
Timminco Limited	Process	2489	2.501	1.412
	Stormwater	122	5.839	2.610

LTAF = Long term average flow rate (m^3/d)

VF1 = Daily variability factor

VF4 = Monthly four day variability factor

(1) No values of VF1 and VF4 were reported in the MISA study. The values in the table are the mean of the values for the first four lime producers.

(2) No flow data was recorded during the MISA study. The values in the table were provided in a personal communication from Ontario Lime Producers.

TABLE 8-7: EFFLUENT FLOW RATE DATA (CONTINUED)

CATEGORIES: BASALT, GRAPHITE, GYPSUM, NEPHELINE SYENITE AND TALC

NAME OF PLANT	EFFLUENT	LTAF	VF1	VF4
3M Canada	Quarry	891	1.223	1.387
Cal Graphite	Process	11391	5.246	2.020
CGC	Process	5499	2.763	1.473
	Mine	4007	3.908	1.927
Westroc	Mine	1198	3.042	1.536
Domtar	Process	4699	4.272	1.807
	Mine	2840	4.047	1.756
Unimin	Process	565	11.501	3.466
Luzenac	Mine	633	2.514	1.535
	Process	516	2.536	1.543
Canada Talc	Mine	4120	5.222	2.015

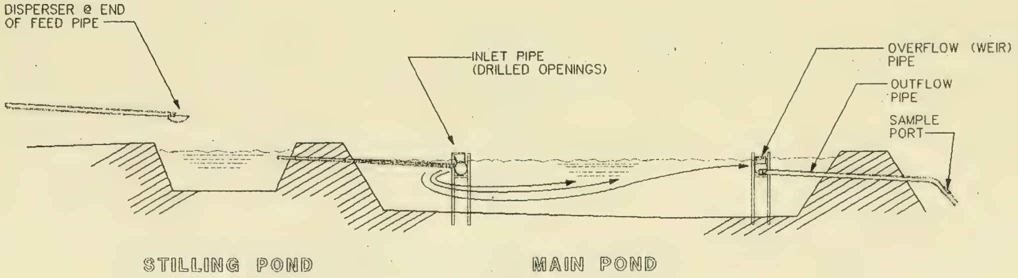
CATEGORY: SALT

NAME OF PLANT	EFFLUENT	LTAF	VF1	VF4
Canadian Salt	Rock salt mine	409	1.341	1.086
	Brine operation	23,000	2.409	1.834
Sifto Salt	Rock salt mine	71	1.615	1.194
	Brine operation	8180	1.867	1.353

LTAF = Long term average flow rate (m^3/d)

VF1 = Daily variability factor

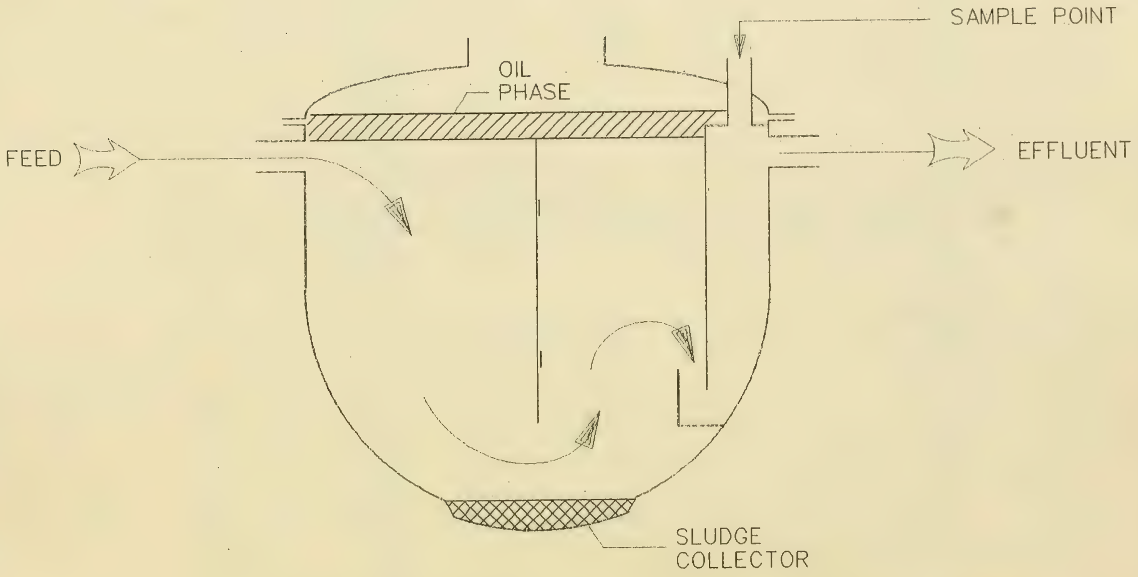
VF4 = Monthly four day variability factor



KILBORN

GENERAL ARRANGEMENT
OF SETTLING POND

DRAWING NUMBER
FIGURE 8-1



OIL / GREASE INTERCEPTOR

KILBORN

GENERAL ARRANGEMENT OF
OIL/GREASE INTERCEPTOR

DRAWING NUMBER
FIGURE 8-2

SECTION 9.
POLLUTION PREVENTION PRACTICES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

9. POLLUTION PREVENTION PRACTICES

Pollution Prevention Practices (PPP) are those activities, infrastructure, and/or facilities, which are employed in order to minimize the potential for, or impact of, an operation on surrounding surface waters. The PPP's which apply to the Non-Metallic Mineral Sector may be subdivided according to whether the practice is specific to a certain mineral category, or whether it may be applied within the entire sector.

PPP's differ from BAT's in that they tend to control pollutants at source and provide control of upsets, rather than provide treatment of ensuing effluent. The degree of pollution prevention achieved through use of PPP therefore tends to be more variable and difficult to quantify. PPP can also be viewed in some instances, such as operator training, as a means of optimizing BAT performance.

For these reasons, PPP's are not regarded as being equivalent to BAT's. In certain cases, and particularly for the Non-Metallic Minerals Division where good housekeeping plays such an important role in pollution prevention, the implementation of a PPP program may successfully fulfil the role of BAT.

9.1 BEST MANAGEMENT PRACTICES (BMP)

This section addresses those management practices which, although they possibly are employed within only one Non-Metallic Mineral Sector category (or outside of the sector entirely), may be applied to a variety of Non-Metallic Mineral Sector operations. Best Management Practices such as; drainage management, spill management, management of materials storage, and rehabilitation, form a major part of Pollution Prevention Practices.

9.1.1 Drainage Management

The management practice which may have the greatest positive impact on effluent quality is drainage control. Drainage control may be categorized as either:

i) preventative in nature, designed to reduce the amount of water inputs to the system, and hence the amount of effluent requiring treatment, or

ii) controls designed to minimize the quantity of contaminant entering into the effluent stream.

The two categories are treated separately but are not necessarily exclusive.

Preventative Measures

Within the Non-Metallic Minerals Division, there are a broad range of effluent types represented. The largest individual source of water requiring discharge generally arises from precipitation (direct or as surface runoff) or ground water. The proper management or segregation of these sources can significantly reduce the amount of contaminated water produced by the operation, and hence, the amount requiring treatment. Installation of measuring devices, control devices and where applicable, level sensors will aid the collection of water flow data which can be used to develop a management strategy.

Surface Water:

The principal means of controlling the amount of surface water input to the operation is to divert catchment areas away from the site or working areas, where practical, or to design and implement a stormwater management plan.

While the main benefit of this practice is to reduce the surface water inputs requiring treatment, (thereby reducing design requirements and operating costs of the system), there are other positive aspects to this practice. By minimizing the surface water inputs to the treatment system, it reduces the chance of treatment system overload during peak inputs from storms or spring run-off.

The diversion of surface waters away from the site, where practical, also reduces the opportunity for foreign contaminants to enter onto the site. It was noted during visits to several sites in Ontario, that off-site water inputs sometimes appear to carry elevated levels of suspended solids and may carry other contaminants of a higher concentration than effluents generated by the operation itself. Surface waters may be contaminated by run-off from public roads, or agricultural lands, for example. Run-off from public roads introduce contaminants such as oil and grease, while runoff from agricultural lands could introduce suspended solids, ammonia/ammonium, nitrate, phosphorus, pesticides and other contaminants, into the effluent of the operation.

Groundwater:

Groundwater management at surface operations can also reduce the volume of effluent requiring treatment. Discussions with personnel involved directly in non-metallic mineral operations, suggested

that groundwater inputs as high as 4000 to 7500 m^3 per day along a quarry face may occur. This is especially true of limestone quarries (associated with Cement, Chemical Lime and Magnesium operations), where springs along the quarry face may have peak discharges during snow melt conditions, or in association with storm events.

In order to reduce the contamination of ground water, flows should be intercepted and diverted away from all workings to the extent possible. This can best be accomplished by excavating ditches close to the non-working faces of pits or quarries. Ditches along working faces are impractical as they would interfere with operations. In addition, a ditch located along the face at the quarry/pit sink, would serve to collect surface waters as well, rather than segregate uncontaminated ground water.

Collection of ground water within underground operations, is a standard procedure using sumps and pumping to the surface. Minewaters often contain suspended solids as well as ammonia/ammonium resulting from blasting agents, and as a result, may require treatment. Segregation is not possible unless the groundwater is intercepted at one or several specific locations and pumped, separately from other water, to the surface.

Minimize Level of Contamination

The most common method of limiting contamination utilized within the Non-Metallic Minerals Division is the strategic placement of ditches throughout the site. Although the practice applies best to those operations with surface workings, it may also be applied to other operations. Control of erosion and surface exposures of stockpiles is also critical to the restriction of contaminant loading at source.

If properly placed, ditches should collect virtually all surface run-off and divert it away from roads, storage piles and other facilities. By collecting the run-off immediately, the potential for contamination is minimized both directly and indirectly. Direct contamination may occur whenever there is surface water present. Indirect contamination may occur as vehicles pass through standing water and then become covered in mud and other materials which must be removed by washing.

9.1.2 Spill Management

Spills of materials associated with site operations (such as raw materials, reagents, fuel) may occur even under the best of procedures, and may result in the contamination of site water. Thus, the BMP is to minimize the potential for spillage, and to control any impact if a spill occurs.

The best procedure for control of all spills, no matter what the substance, or how small the spill, is to provide proper spill containment facilities as part of the plant site design and to practice specific spill clean up strategies. Although a spill of raw materials may not pose a real danger, the uncontained material spills may contaminate surface runoff. Of specific concern is the proper clean up and disposal of spilled fuels or blasting agents. The explosive most commonly used in mining operations is a mixture of ammonium nitrate and fuel oil (ANFO), containing approximately 95% ammonium nitrate. This material dissolves rapidly in water, and hence any ANFO spills (or spills of ammonium nitrate) should be cleaned up immediately. ANFO spills are commonly regarded as the main cause of elevated concentrations of ammonia/ammonium in quarry or minewater.

In the case of most material, clean up will entail only the removal of materials by shovel, or other means. In the case of petroleum products as well as hazardous materials, special handling procedures are required. Plant personnel associated with these materials should be trained in their proper handling, clean up and disposal procedures. Clean up materials such as absorbants should be present at all times.

In order to minimize the potential impact of spills, spill containment structures should also be placed around storage locations. Commonly ditches or berms are used to contain any spills or leakages until they can be managed according to the applicable regulations.

9.1.3 Storage Management

Proper storage practices in addition to those already mentioned under spill management, may help reduce the amount of suspended solids released to surrounding surface waters by non-metallic mineral operations. Runoff from raw material storage piles is a major source of this sediment. Although it is not necessarily practical for all materials to be covered, those materials that are highly soluble, or are easily washed away, should be covered, or their drainage should be contained and segregated from other site run-off.

A practice that is already in use in Ontario, is the development of a lined ditch encircling coal/coke storage piles connected to a storage sump. The ditch/sump has sufficient storage capacity so that all runoff from the piles is collected, and evaporates naturally. Evaporation can be enhanced and dust generations from the piles reduced, by periodically spraying the piles with water recycled from the sump. In this way coal/coke fines remain at the storage location, and are not transferred elsewhere on-site.

Another way to limit contaminant release from storage piles, is the development of a wind screen to block the prevailing wind direction. By limiting the amount of dust released into the atmosphere, indirectly the amount of contaminant in the surface water is reduced. These screens may be either developed specifically for wind control, such as a screen of trees; or the storage piles may be located so as to take advantage of the conditions downwind of a large building or other structure.

9.1.4 Rehabilitation

Progressive rehabilitation may significantly reduce the quantity of fine material released into surface waters. Grading of slopes and revegetation decreases the amount of sediment picked up by surface run-off, and also sharply decreases the amount of material that can be entrained by winds, to be deposited and later re-entrained, by runoff.

Open Pit Operations

In order to facilitate progressive rehabilitation, where practical topsoil should be stockpiled separate from other overburden. Ideally, as an area is stripped, the overburden is moved directly to the area needing rehabilitation, so that no intervening stockpiling, except for topsoil, is required.

Underground Operations

Although progressive rehabilitation applies more appropriately to those operations with surface workings, these practices may also be applied to waste rock storage areas, and tailings ponds. In the case of waste rock piles, initial development should ensure that the waste rock storage areas are levelled as soon as possible after they are formed. Depending upon the type of rock, this material may be used on-site for road development and general yard surfacing, or in construction of settling ponds and tailings dams.

9.1.5 Cooling Water Management

The major source of effluent water from many non-metallic mineral operations is once-through non-contact cooling water. Care should be taken during normal operations to ensure that the cooling water remains non-contact, and does not become contaminated with material from the plant site such as solids or oil and grease. Ideally, non-contact cooling water should be cooled and recycled via either a cooling tower, or engineered ponds. One small white portland cement producer in Ontario, has been able to achieve zero discharge by employing this method. (Federal White)

At other operations in Ontario, 100% recycle of cooling water may not be practical. At these operations, the most appropriate form of cooling water management may be complete or partial segregation of non-contact cooling water from other effluent streams. In this way the large, uncontaminated flow of cooling water does not become contaminated by a smaller quantity of contaminated effluent. If complete segregation of cooling water is employed, the cooling water may not require treatment as waste water.

Partial segregation of effluent streams may also be helpful in reducing the quantity of effluent requiring treatment, or the amount of treatment required. Partial segregation may involve the segregation of plant site effluent from quarry effluent; or in general, less contaminated effluent streams from heavily contaminated streams.

9.2 WATER REUSE / CONSERVATION

Wherever possible, all process and wash water should be recirculated, and not drawn from local rivers or lakes. In most instances, there is a ready source of water available either in the settling or tailings ponds, or quarry sump.

Recycle is practised to some extent at most non-metallic mineral operations. At those operations with equipment washing facilities, the water may be drawn from settling ponds or other on-site sources. Depending upon the availability of this source (related principally to the time of year), and the quality of the water, supplemental water may be drawn from off-site sources as required.

The other major re-use of water possible on-site within most non-metallic mineral operations, is for dust control. This is applicable to all non-metallic mineral operations, but especially to sites with open pits or outdoor storage of fine raw materials. Effluent may be sprayed on stockpiles, working areas and roads to control dust during dry weather.

Application of these practises at those non-metallic mineral operations where appropriate could aid in decreasing the amount of effluent requiring treatment and discharge off-site.

Those non-metallic mineral categories where other types of water recycle is practical are discussed briefly below.

Cement

In order to minimize the quantity of effluent released to the environment, effluent should be recirculated to either the process, or for cooling wherever practical. This may require the use of cooling towers, or

the development of ponds designed specifically for cooling the effluent. In addition to reducing the effluent released, this practice will ensure a source of cooling water for the operations at all times, while only requiring periodic withdrawals from other sources.

As required, surplus water could also be used for dust control, or equipment washings on-site.

Graphite

Since the majority of the effluent released off-site from the single Ontario graphite producer results from process water, initiation of recycling from the polishing pond (as currently proposed by the operation), should substantially decrease the amount of water discharged to the environment.

Basalt

Extensive recycle is currently practised by the single basalt producer in Ontario, since all process water is currently recycled to the process. Surface runoff and quarry water however, is not recycled, although a quantity may possibly be reused for washing or dust control.

Salt

In addition to the potential reuses of water for equipment washing and dust control at rock salt operations, brine well operations may be able to recycle some of the effluent back into the brine well system. This is however, highly dependant upon the individual operation.

9.3 PROCESS CHANGE

Processing or benefication techniques used in the Non-Metallic Minerals Division are selected for each specific plant based on mineralogical and chemical properties of the raw materials, market demands for the product and the technical feasibility of optimizing extraction rates.

Many of the processes are dry but where wet processing is selected this choice is driven more by the nature of the raw material or desired end product, rather than the availability of suitable water supplies or disposal systems. Process changes to reduce or eliminate water use are unlikely to be feasible other than for auxiliary systems such as scrubbing units and coolers. It is unlikely therefore that technically feasible process changes can be effected which will have a major impact on effluent water quality.

9.4 CATEGORY SPECIFIC BEST MANAGEMENT PRACTICES

Portland Cement

In order to ensure neither a loss in raw materials, nor the contamination of surface run-off, where practical raw materials should be either stored indoors or in covered piles. Where this is not practical, drainage should be collected from the piles and either treated separate from other effluent streams, or allowed to evaporate naturally. A special case is the disposal of kiln dust since its fine texture makes it readily entrained by either the wind or by surface run-off. At most operations kiln dust is delivered to a landfill site where containment and covering ensure that losses by entrainment are minimized.

Chemical Lime

In order to limit the loading of surface waters with lime, all waste lime should be disposed of as soon as practical. This may require designation of an area within a worked out portion of the quarry for lime disposal, in order to limit double handling of the waste product, and ensure that the waste lime is covered as soon as practical. If the waste product is not covered with overburden periodically, the lime may be entrained by the wind or by surface run-off. The dissolving of the waste material may lead to unacceptably high alkalinity in surface run-off, which may as a result, require pH regulation prior to release.

Graphite

No other BMP are suggested for graphite operations other than the general Best Management Practices summarized previously in Section 9.1.

Gypsum

Although general Best Management Practices should be applied to gypsum mines/plants, the only clarification necessary is that gypsum stored outdoors should either be covered, or the drainage should be collected, and allowed to evaporate.

Consideration towards disposal of waste gypsum underground in unused portions of the mine is encouraged. By applying this practice, there will be less need to collect and treat drainage from waste gypsum piles.

Nepheline Syenite

Since nepheline syenite is a fine textured product, care should be taken to control blowing dust on site which may contaminate surface waters. This may entail the development of wind screens surrounding

the tailings area, as well as wind breaks throughout the property where practical. Progressive rehabilitation of the tailings area will further minimize wind losses.

Basalt

There are few management practices other than the general practices mentioned previously, that apply specifically to basalt operations.

Talc

In order to minimize the amount of fines introduced to run-off, any talc stored outdoors should either be covered, or the drainage should be collected, and treated or allowed to evaporate. Waste talc should be disposed in the underground mine or open pit in unused locations.

Salt - Evaporator Plants

The clean-up of salt spillage may be achieved by washing to a drain or by dry retrieval of the spill. Unless the resulting drainage solution can be recycled to the process, dry methods should be used wherever possible to minimize contamination of additional water.

Water with a low level of contaminant should be kept segregated from highly concentrated water, such as bleeds, scrubber effluent, and tank overflows. This will ensure that a smaller quantity of water will require treatment prior to release.

Salt - Rock Salt Producers

One of the critical issues for salt producers is the ability to store a sufficient amount of salt to be able to meet winter demands. This quantity may be very large, and storage facilities may require room for up to 400,000 tonnes of salt (Letts, 1991). Ideally, these storage facilities would be within the mine itself, or if on the surface they should be covered. Although these options may not always be practical, they should be applied to the maximum extent possible. If salt is stored outdoors uncovered, the storage should be on an impermeable pad so that all run-off can be collected and treated without contaminating local surface water or groundwater.

SECTION 10.

ZERO DISCHARGE

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

10. ZERO DISCHARGE

10.1 ZERO EFFLUENT DISCHARGE

Zero volume discharge is regulated and readily attainable for operations in dry and/or arid climates, which are characterized by net surface evaporation. These practices would apply for example, at operations within the southern and western regions of the United States. In Ontario, annual precipitation exceeds maximum annual open water evaporation by 200 to 500 mm annually. As a result, a net surplus of water is collected at any given site via processes of surface runoff, precipitation and groundwater inputs. Natural evaporation processes are not capable of eliminating this water accumulation, and water volume reduction can be achieved only through treatment systems or process water use where applicable.

Where practical, on-site water requirements may be drawn from this net water accumulation, and may decrease or eliminate the amount of water which would otherwise be discharged off-site as effluent. Generally the water accumulated at the site via storm water runoff, groundwater inputs and precipitation is greater than potential water loss associated with on-site reuse or recycle. As mentioned in Section 9.2 previously, implementation of reuse and recycle on-site could however, significantly reduce the volume of effluent requiring treatment and discharge.

It is unlikely however, that any of the non-metallic mineral producers in Ontario would be able to reach zero discharge of effluent without the implementation of large-scale evaporators. Large-scale evaporators are not currently utilized at any non-metallic mineral operation worldwide. The potential economic cost to the operation, and cost to the environment of utilizing the required amount of energy for evaporation of large quantities of water, make this an impractical solution.

10.2 VIRTUAL ELIMINATION OF TOXICS

Preliminary data from the MISA study indicate that at least one operation within seven of the nine non-metallic mineral categories monitored releases an effluent which is non-lethal or considered non-toxic to either Daphnia magna or Rainbow Trout. The toxicity is based upon an LC50 test on these organisms for 48 hours or 96 hours respectively. Based on these preliminary data, it appears that a non-toxic

effluent may be achievable by operations within these seven categories. At the time of writing, there is insufficient information available to address toxicity in greater detail within these categories.

The only categories monitored which did not have a single operation with a non-toxic effluent were Nepheline Syenite (only 1 operation) and Salt (2 brine well /2 rock salt operations). At the Nepheline Syenite operation, of three samples taken, only one was considered toxic. Of the twelve samples taken and analyzed for toxicity from Sifto Salt, Goderich (various effluent streams), four samples were considered toxic to Daphnia magna, while only one sample was toxic to Rainbow Trout. Of the eighteen samples collected at the Canadian Salt Company, Windsor (various effluent streams), five samples were toxic to Daphnia magna, while four samples were considered toxic to Rainbow Trout. As with the other categories, there is insufficient information available to address toxicity at these sites in greater detail.

SECTION 11.

SUMMARY AND CONCLUSIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
NON-METALLIC MINERALS DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

11. SUMMARY AND CONCLUSIONS

11.1 FULFILMENT OF THE STUDY OBJECTIVES

The principle objectives defined in the terms of reference are the following:

(1) to develop an inventory of water pollution control technologies presently used in the recovery and processing of industrial minerals worldwide, focusing on design, operating conditions, performance and capital and operating costs.

(2) to develop an inventory of generic waste water pollution control technologies used in other industrial sectors, which could be applied to the industrial minerals sector

(3) to identify, where possible, up to five technology trains which can be applied to different plant types to achieve BAT option goals, and

(4) to estimate performance and capital costs for selected BAT options.

Within the limitations of the data, all of the above objectives are met. The inventory developed in connection with objective (1) above, focuses primarily on Ontario operations (24% of listed operations), Canada outside of Ontario, (25% of listed operations), the United States (36% of listed operations), and Europe (15% of listed operations). The bias towards Ontario operations reflects: (1) emphasis of the defined study scope on Ontario operations, (2) the wealth of data generated for Ontario operations through the MISA monitoring program, compared to that available for other countries and provinces, (3) a diverse geological setting in Ontario which is conducive to the occurrence of a wide range of industrial minerals and (4) in many instances a lack of success on the part of study team members to solicit information or confirmed water quality data from operations outside of Ontario.

Preparation of the generic waste water control technologies is comprehensive. However, for various reasons, mostly relating to the limited variety and inoffensive nature of contaminants released, and cost implications; very few of these generic technologies are actually employed in the industry. Where more

unusual waste water control technologies are employed, the application is frequently very specific to one or more non-metallic mineral categories.

Therefore, for reasons stated above, the study team is unable to define a large number of applicable BAT technologies. The most common technologies employed are sumps and settling ponds/tailings ponds, arranged in various ways. The industry, to a large extent, relies more heavily on Pollution Prevention Practices (PPP) and Best Management Practices (BMP), rather than on a variety of waste water treatment technologies.

Based on preliminary toxicity from the MISA program, only two categories of non-metallic minerals did not have an operation which produced a non-toxic effluent: nepheline syenite and salt. There is insufficient data available to address toxicity in detail.

Performance of the existing treatment technologies is very difficult to evaluate. The primary reason is that many of the effluent treatment systems (principally settling ponds) have not been engineered or otherwise specifically designed to any expected set of performance standards. The MISA program did not monitor influent water quality or otherwise assess the actual addition of contaminants to naturally occurring water flow by the specific operations. In addition, since much of the effluent released derives from run-off and groundwater inputs, such flows are highly variable in volume, leading to extremes in pond retention times.

11.2 DATA LIMITATIONS

Owing to the limited concern for contaminants, other than suspended solids, associated with most industrial mineral quarrying and process operations, this industrial sector has received limited attention world-wide, as compared to other sectors such as metal mining. Waste water monitoring at many operations is consequently of limited extent, and where present is generally restricted to suspended solids and pH. Toxicity testing is all but non-existent, other than that associated with the Ontario MISA monitoring programme. The preliminary MISA toxicity data available are discussed breifly within this document.

Since non-metallic mineral operations tend to be of local rather than international importance, regulatory controls are most often administered at the municipal or local level. This is in contrast to sectors such as metal mining where national/international concerns have been expressed regarding heavy metal and other contaminants. Exchanges of environmental data and control technologies are consequently quite limited in relation to the Non-Metallic Minerals Division.

11.3 APPROACH TO THE SELECTION OF BAT OPTIONS

Emphasis in the selection of BAT options is placed on: (1) the control of selected contaminants, (2) demonstrated use of waste water treatment technologies within the Non-Metallic Mineral Division, and (3) the feasible application of technologies employed in other industrial sectors of the industry.

Evaluation of the need to control selected contaminants is based on MISA monitoring data, and on the perceived need of industry members to control such contaminants, as reflected in the world-wide use of control technologies. Following compilation of the Non-Metallic Mineral Division inventory (Section 7) it is evident that most waste water treatment systems in use, are directed at the control of suspended solids, and more rarely, the control of oil and grease, or pH.

11.4 COMPARISON OF REGULATORY STANDARDS

In reviewing regulatory standards world-wide for parameters of interest, most notably pH, suspended solids, and oil and grease, there is general consensus on pH and oil and grease, but not for suspended solids. Typically, pH is regulated within the range of 5.5 to 9.5 Oil and grease is generally limited at 10-15 mg/L; with the lowest standard at 5 mg/L.

Guidelines and regulations governing concentrations of suspended solids range from a low of 15 mg/L in Ontario to a high of 100 mg/L in Germany. The 'U.S. EPA Code' applicable to the Industrial Mineral Sector recommended suspended solids limits of from 10-20 mg/L for graphite operations, and 30 mg/L for minewater associated with gypsum production. Limits proposed for other sub-sectors, such as talc and salt, are expressed as weight of contaminants per weight of product, rather than as concentrations. Only some of these guidelines initially recommended within the Development Document for Effluent Guidelines and Standards (1979) have been adopted into regulations.

In other Canadian provinces, and at the Federal level, guidelines/regulation limits for suspended solids typically range from 25-50 mg/L. European limits range from about 30-100 mg/L in the countries reviewed.

The Ontario guideline is therefore generally more stringent than those of any of the other areas investigated.

11.5 BAT LEVEL OPTIONS

Selected Best Available Technologies have been identified on a parameter basis for control of suspended solids (other than those associated with mill discharges from graphite, gypsum, nepheline syenite and talc plants) sumps and settling ponds are recognized as the BAT. Tailings ponds in combination with polishing ponds and, in some instances, passive filtration are regarded as the BAT for mill discharges. For pH control, the addition of sulphuric acid or liquid carbon dioxide is regarded as the BAT.

There are no demonstrated Best Available Technologies for the control of oil and grease, ammonia and phenolics. These parameters, except in isolated cases, are not present at levels judged to be treatable by demonstrated treatment methods and are best handled through implementation of Best Management Practices to primarily control pollutants at source.

An Ontario BAT plant was chosen, where possible, in each of the nine non-metallic mineral categories. BAT plants selected on the basis of US EPA standards and to represent the rest of the world, could not be identified in some categories due to insufficient information, or a lack of known sister plants.

The capital and operating costs to attain the levels of Ontario BAT, US BAT and World BAT are estimated, where possible, for all of the plants in each category. The issues of non-toxic effluent, Zero Discharge and Maximum Pollution Prevention are addressed by providing cost information on preferred BAT wherever possible.

11.6 POLLUTION PREVENTION PRACTICES

Pollution Prevention Practices (PPP) are those activities, infrastructure, and/or facilities, which are used in order to minimize the potential for, or impact of, a non-metallic mineral operation on surrounding surface waters. The PPP's which apply to the Non-Metallic Minerals Division may be subdivided according to whether the practice is specific to a certain category, or whether it may be applied universally within the entire division. Pollution Prevention Practices include Best Management Practices (BMP).

PPP's differ from BAT's in that they tend to control pollutants at source and provide control of upsets, rather than to provide effluent treatment per se. The degree of pollution prevention achieved through use of these practices therefore tends to be more variable and difficult to quantify. BMP's can be viewed in some instances as means of achieving BAT performance.

For these reasons, PPP's are not regarded as being equivalent to BAT's. However, in certain cases, and particularly for the Non-Metallic Minerals Division where good housekeeping plays such an important role in pollution prevention, the implementation of a PPP program may successfully fulfil the role of BAT.

The PPP's which are most relevant to the Non-Metallic Minerals Division include: recycle of effluent where practical, reuse of effluent for dust control, and cooling water management (cement).

The quantity of effluent requiring treatment may be reduced by recirculating cooling water to the maximum practical extent. In addition, process and wash water should be recirculated, wherever possible, in order to minimize the amount of water drawn from natural water sources.

The PPP's which best apply to the Non-Metallic Minerals Division involve:

- drainage management
- spill management
- storage management
- rehabilitation, and
- cooling water management

Drainage management may involve a reduction in the amount of water inputs, and hence the amount of effluent requiring treatment; and/or, a minimization of the quantity of contaminant entering the effluent stream.

Proper spill management through the placement of spill containment structures around storage areas, and the immediate clean up of all spills using appropriate techniques, may significantly reduce the amount of contaminants entering the effluent stream.

Storage management within the Non-Metallic Minerals Division may inhibit the entrainment of raw materials, and thereby reduce the amount of suspended solids released to surrounding surface waters by runoff.

Progressive rehabilitation may also significantly reduce sediment inputs to the waste water stream. Grading of slopes and revegetation reduces the amount of material available for entrainment by winds or runoff.

In addition, where relevant, proper cooling water management may significantly improve effluent quality/quantity.

11.7 ZERO DISCHARGE AND VIRTUAL ELIMINATION OF TOXICS

Zero volume discharge is readily attainable throughout much of the south and west of the United States, because the mean annual evaporation exceeds mean annual precipitation. In Ontario, there is a net precipitation surplus (200-500 mm) in all areas. Zero volume discharge is therefore only possible for those selected operations which use a high rate of recycle, in combination with process evaporative losses.

Progress towards 'zero volume discharge' can nevertheless be made through use of maximum reuse and recycle (Pollution Prevention Practices).

Based upon preliminary toxicity data from the MISA program, it appears that excluding nepheline syenite and salt, all categories within the Non-Metallic Mineral Division have at least one operation which discharges an effluent non-toxic to both Daphnia Magna and Rainbow Trout (based upon LC50 tests of 48 hours and 96 hours respectively). At this preliminary stage, it appears that a non-toxic effluent may be achievable by operations within these categories. There is insufficient information available at the time of writing to further address toxicity within this Division.

SECTION 12.

REFERENCES AND SELECTED BIBLIOGRAPHY

ONTARIO MINISTRY OF THE ENVIRONMENT
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12. REFERENCES AND SELECTED BIBLIOGRAPHY

Ontario Ministry of Natural Resources, 1989, Limestone Industries of Ontario, Volume I, II and III.

Environmental Protection Agency, 1974. Development Document for Effluent Limitations Guidelines and New Sources Performance Standards for the Cement Manufacturing Point Source Category.

Environmental Protection Agency, 1979. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the General Manufacturing Point Source Category.

Coope, B. ed., 1982, Industrial Minerals Directory, Metal Bulletin Books, England.

Safety and Health Technology Center, U.S. Department of Labour, 1991. Listing of Surface Metal/Nonmetal Mines.

Ontario Ministry of the Environment. 1984. Water Management, Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. Revised May 1984.

Ontario Ministry of the Environment. 1991. MISA Monitoring Database Guide Draft Version 1.

Mining Journal, London. 1991. Mining Annual Review.

Funke, D.M. and P.M. Terlecky, 1982. Suspended Solids Removal in the Crushed Stone Industry. Prepared for U.S. EPA Effluent Guidelines Division.

Energy Mines and Resources Canada, 1990, Canadian Minerals Yearbook.

Ontario Ministry of Natural Resources, 1982, Ontario Industrial Minerals, Industrial Mineral Background Paper 2.

Portland Cement Association, 1989, U.S. and Canadian Portland Cement Industry: Plant Information Summary.

Ontario Ministry of the Environment, 1990. MISA - The Development Document for the Effluent Monitoring Regulation for the Industrial Minerals Sector.

Ontario Ministry of the Environment, 1991, Best Available Pollution Control Technology, Metal Mining Sector.

Environment Canada Wastewater Technology Center, 1990 Technologies for the Treatment of High Salinity Effluents from Salt Mining and Processing.

Ontario Ministry of the Environment, 1991, Request for Proposal Industrial Minerals Sector: BAT for Pollution Control in Ontario Industrial Minerals Sector Plants.